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PRIMARY BONE TUMORS IN CHILDREN

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BONE tumors occur in children with a somewhat greater frequency than has been generally supposed, primary malignant bone tumors occurring rather more frequently in them than in adults. Except for the fact that because of the age factor a less satisfactory history can be elicited in children, there is no material difference between children and adults as regards symptomatology, physical findings, diagnosis, treatment, and prognosis of bone tumors.

In 16,000 admissions at the Orthopedic Hospital, 89 bone tumors have been recognized, an incidence of one in 180. To this group of cases were added 28 from the Yale Street Clinic, making a total of 117 cases. Twenty-two, or 18.6 per cent, of these were malignant tumors, while 95, or 81.4 per cent, were benign tumors, the group being divided as follows:

Sarcoma	16
Endothelioma	6
Neurocytoma (metastatic)	1
Osteoma and osteochondroma	73
Giant-cell tumors	8
Bone cysts	8
Enchondroma	4
Odontoma	1
	117

The general incidence of bone tumors to admissions has been one tumor to 180 admissions, an incidence of approximately 0.5 per cent. There has been one malignant tumor to 888 admissions. The majority of these were sarcomas, of which there was one case in 1200 admissions. These figures may be compared with those obtained in a large private clinic in which the incidence of sarcoma was one to 4000 admissions. The increased incidence noted in our series is, of course, due in part to the fact that the Orthopedic Hospital is exclusively for patients suffering from bone and joint diseases, but it is also due in part to the fact that it is exclusively for children.

There have been innumerable attempts at classification of bone tumors, as a result of which there is considerable confusion in the literature as to the terminology of these growths. At the risk of adding to this confusion we suggest the following method of classification:

I. Tumors arising from osteogenetic elements
  (*a*) Osteoma, osteochondroma, exostoses
  (*b*) Chondromyxoma, enchondroma, chondroma
  (*c*) Chondromyxosarcoma
    (1) Primary
    (2) Secondary
  (*d*) Osteogenic sarcoma
    (1) Osteoblastic
    (2) Osteolytic
  (*e*) Bone cysts
  (*f*) Giant-cell tumor
II. Tumors arising from tissues resident in bone
  (*a*) Diffuse endothelial myeloma (Ewing's tumor)
  (*b*) Myeloma
  (*c*) Fibrosarcoma
  (*d*) Neurosarcoma
III. Tumors metastasizing to bone.

Willis Campbell thinks that all malig-

Fig. 1. See text.

nant osteogenic tumors should be included under the general heading of osteogenic sarcoma, a method which, without doubt, would serve to simplify greatly the rather confused terminology. The prognosis, however, and hence the treatment of osteolytic osteogenic sarcoma is somewhat different from that of, *e.g.*, secondary chondromyxosarcoma, and it may be that the additional qualifying statements needed to emphasize this point would serve to lessen the gain which might result from the simplification hoped for.

I. TUMORS ARISING FROM OSTEOGENETIC ELEMENTS

Osteomas are circumscribed overgrowths of bone which, histologically, cannot usually be distinguished from simple hyperplastic growth of bone. Although strictly speaking the term "osteoma" should be applied only to true neoplasms, in practice all forms of bony overgrowth will be included.

There were 23 of these tumors in our series, distributed as follows:

Femur.....	10	Fibula.....	1
Tibia.....	5	Scapula.....	1
Humerus....	5	Mandible....	1

The age of incidence was from eight to 19 years, the average age being 13 years. The tumor was just noticed at the average age of ten years and four months, an age which coincides with the beginning of the period of rapid growth.

These tumors are purely productive, and are composed solely of bone tissue. They commonly arise in the cortical portion of the bone, which they do not destroy. They may assume any shape, the rather flat "table top" type (Fig. 1) being common. They grow slowly, do not metastasize, and show no tendency to invasion of the adjacent tissues. These are the characteristics which might be expected in a benign tumor. They cause no symptoms directly, but indirectly they may produce pain by the slipping of tendons or muscles over the bony mass, or they may cause limitation of motion by blocking joints. They should be treated by surgical removal when and if they cause any symptoms.

Osteochondromas (Fig. 2) are benign productive tumors arising from the precartilaginous connective tissue elements in bone. They do not differ greatly from the osteomas in their symptomatology and objective findings.

Of the 40 cases of osteochondroma in this series the involvement of bones was as follows:

Multiple bones.	11	Carpal.....	1
Tibia.....	10	Fibula.....	1
Femur.....	9	Ilium.....	1
Scapula.....	6	Vertebra.....	1

They were equally divided as to sex, and the age at admission was from new-born to 14 years, with an average age of three years. Pain was present in only eight cases. Twenty-two patients underwent excision of the tumor, with recurrence in three cases, a percentage of 13.6. The treatment of choice is excision. There is a moderate tendency to recurrence which may be controlled by post-operative irradiation. Roentgenologically, these tumors exhibit a bony base, arising from an intact cortex, and an irregular surface with multiple translucent areas. These areas and the irregularity of the surface reflect the occurrence of the cartilaginous cap and islands characteristic of this tumor. Osteochondromas may be multiple and are frequently very large. The tumor occasionally undergoes malignant degeneration, resulting in the formation of a secondary chondromyxosarcoma.

Exostoses (Fig. 3) are merely small osteochondromas. They commonly arise near joints and their cartilaginous tips are always directed away from the nearest

Fig. 2. See text.

Fig. 3. See text.

Fig. 4. See text.

joint. They are frequently multiple, and are occasionally seen in multiple form in hereditary deforming achondroplasia (Fig. 4). Many, perhaps even most, exostoses are of inflammatory or traumatic origin, and, strictly speaking, are not tumors.

Chondromas or *Enchondromas* are rather common tumors, arising from cartilage cells (Fig. 5). Four of these growths were encountered, two of which occurred in males and two in females. The complaint in every instance was swelling; none complained of pain. In one case the tumor was in a metacarpal, while the other three exhibited multiple growths in the phalanges. One case was recurrent ten years after excision. These tumors are benign, arise in the medulla, grow slowly, expand the bone, and rupture the cortex when they become large enough to do so by pressure. They are hard, round, lobulated tumors, often very large. Certain of these tumors are softer and more cellular, containing some myxomatous elements, and these are often called chondromyxomas. They are occasionally described as arising from the cortical structure of long bones, near their epiphyses, but Geschickter and Copeland think that these are really osteochondromas with very large cartilaginous caps. They occur in the diaphyses of bones near the epiphyses; their commonest locations are the metacarpals, the metatarsals, and the phalanges. They are frequently multiple. It is usually stated that these tumors cause some pain, but our observation is that the first symptom is commonly fracture resulting from rather trivial trauma. From the standpoint of roentgen analysis these are central tumors, expanding the bone, with or without trabeculations, breaking through the cortex by pressure only, and frequently multiple (although Geschickter and Copeland state that they rarely are). All of them occur within the first two or three decades of life. They produce no bone, although callus formation may occur after rupture of the cortex.

They are best treated by excision, but, if too large for complete removal, the

Fig. 5. See text.

either primary or secondary and are among those classified by Campbell as primary and secondary osteogenic sarcomas.

Primary.—It is probable that most of these tumors are diagnosed and classified as periosteal sarcomas, since they are of peripheral rather than central origin, and not infrequently exhibit the rather classical "sun-ray" arrangement of thin calcified plaques. They originate in remains of embryonal cartilage, grow with great rapidity, and tend to encircle the bone (Figs. 6 and 7). There is, at least in their early stages, little or no cortical destruction (or at any rate none that is apparent in the roentgenogram), although early cortical destruction is one of the distinguishing features of

Fig. 6. See text.

Fig. 7. See text.

Fig. 8. See text.

surgery should be followed by irradiation therapy. There is a considerable tendency for chondromas to recur. Very large chondromatous tumors, especially those occurring in long bones, should be regarded as potentially malignant, and the bone should be subjected to irradiation after removal of the tumor.

Chondrosarcomas and *Chondromyxosarcomas* are malignant tumors which may be malignant tumors. Their principal x-ray characteristics are their homogeneous low density and their extreme translucency, which has caused them to be described as "invisible tumors." Occasionally small areas of bone formation are seen, or the "sun-ray" appearance referred to above may be noted. These tumors often become very large, and metastasize rather late. The medulla may be invaded by the tumor

mass late in its course. The first symptom is pain, usually mild at first, but rapidly becoming severe. A certain amount of fever and a moderate leukocytosis is not uncommon. These tumors are extremely malignant and are best treated by amputation. In spite of the fact that they are moderately radiosensitive, irradiation therapy seems to be of little use except as a palliative measure, another evidence of the fact that radiosensitivity and curability are not synonyms.

Secondary.—These are malignant tumors containing fibrous, myxomatous, cartilaginous, and osseous elements, arising from the site of lesions ordinarily not malignant, *i.e.*, osteochondromas and exostoses, presumably from embryonal rests within the benign lesion. They occur somewhat later in life than the primary chondrosarcoma, and are not commonly or even very frequently found in children. The history usually extends over several years, the complaints being pain and swelling. These tumors, although malignant, are much less so than the primary growths, and the percentage of five-year cures is considerably higher. Geschickter and Copeland give the following data concerning five-year cures: primary chondrosarcoma, 5 per cent; secondary chondrosarcoma, 24 per cent.

From the standpoint of roentgen findings, and as a general rule, the presence of the originally benign lesion will be recognized. Superimposed upon it will be found the destructive changes of malignancy with a poorly outlined low density mass infiltrating the adjacent tissues: areas of new bone formation and areas of calcification may be found in the invading mass of tumor. Malignant degeneration should always be suspected when these occur, or when there begins a sudden "speeding up" of the symptoms or growth-rate of a benign tumor, such as osteochondroma or chondroma. Secondary chondrosarcoma is best treated by amputation. Perhaps intensive irradiation before and after operation would increase the percentage of cures.

Osteogenic Sarcomas.—These tumors arise from the malignant degeneration of the osteogenetic elements of bone tissue, and the term should be understood to include only those malignant neoplasms which, in some degree, retain the functions of bone production. There are other malignant tumors of bone arising from tissues resident in bone, *e.g.*, Ewing's tumor and myeloma, which are in no sense related to the group of osteogenic sarcoma. The still frequently encountered sub-classification of periosteal and medullary sarcoma should not be employed, partly for the reasons given above, and partly because all sarcomas sooner or later involve the periosteum, cortex, and medulla. They occur most commonly in long bones (although none of the bones are exempt) and always near the epiphyseal ends of the bones, the presence of a newgrowth in the central portion of the shaft making it unlikely that the growth is an osteogenic sarcoma. The femur, tibia, and humerus are usually said to be the favorite locations of this lesion. There are 16 cases of osteogenic sarcoma in our series, 10 of which were in females and six in males. The age of admission was from 18 months to 18 years, the average being 12 years. The history concerning the tumor extended over periods ranging from two weeks to four months and the average duration of symptoms was three months. The following bones were involved:

Femur	10	Humerus	1
Tibia	4	Fibula	1

The results of treatment were as follows:

		Living	Dead
Refused treatment	2		2
Amputation	6	3 (one, 13 mo. after operation; two, 4 mo.)	3
Coley's toxin	2		2
Irradiation	5		5

The duration of life after the onset of the symptoms ranged between four months and four years, the average length of life after the beginning of the disease being 15 months. One patient underwent amputation three and one-half weeks after the appearance of symptoms, and remained

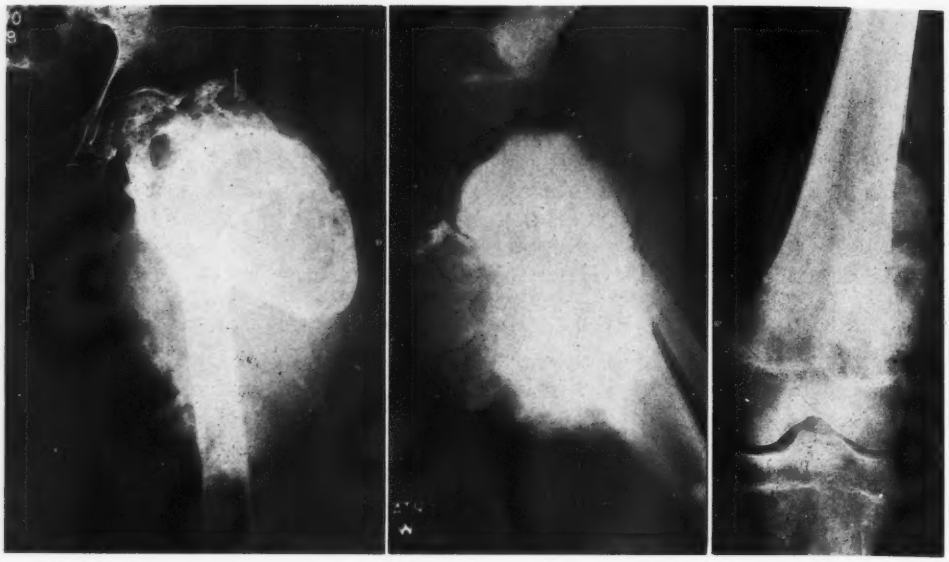


Fig. 9. See text.

Fig. 10. See text.

Fig. 11. See text.

well for three and one-half years but died of pulmonary metastasis at the end of the fourth year. The distribution of metastatic lesions was as follows:

Other bones	13
Lungs	4
Mediastinum	2
Lymphatic system	1

Some of the metastases were multiple, the lungs and one or more bones being simultaneously involved.

The first symptom is usually slight pain and swelling and is generally ascribed to some preceding trivial injury. Instead of improving under usual treatment, and within a reasonable time, the swelling increases, frequently becoming fusiform, and the pain grows steadily more severe. The diagnosis is usually made at this point by x-ray examination, biopsy, or both. Mild fever and a moderate leukocytosis are not infrequently present. The subsequent course of an untreated case depends upon the degree of malignancy of the tumor. The more highly malignant growths frequently destroy life before a great deal of local destruction and tumefaction have been accomplished (Fig. 8). On the other hand, some tumors metastasize comparatively late, giving time for extensive local destruction and for the formation of a huge mass (Fig. 9). It is interesting and important to note that osteogenic sarcomas appear most often (*a*) in the region of most intense bone growth, *i.e.*, the region of the epiphyseal line, and (*b*) at the age period when growth is most rapid.

Although, strictly speaking, all osteogenic sarcomas produce some bone, there are those in which the destructive changes are predominant, while others lay down considerable amounts of new bone. The former may be described as osteolytic osteogenic sarcomas, while the latter are properly described as osteoblastic.

Osteoblastic Osteogenic Sarcoma.—The principal characteristics of this tumor are its sub-periosteal origin, its predominantly productive character, its marked hardness and density to the x-ray (from which it receives its name "sclerosing type"), and the peculiar and characteristic plaques of new bone laid down at right-angles to the cortex. Although mainly productive, destruction occurs in both the cortex and the medulla, causing a mottled appearance of the bone (Fig. 10). The earliest change

demonstrable in the roentgenogram is a slight increase in the bone density. This is followed shortly by the appearance of the characteristic plaques perpendicular to the long axis of the bone. An often much emphasized point is the so-called "lipping," a triangular area of ossification at the point of reflection of the periosteum from the normal bone (Fig. 11). As a matter of fact, this finding, although frequently present, is rather more common in Ewing's tumor than in sarcoma. The point of origin in the epiphyseal end of a long bone is a point of great importance, and bone lesions, whether destructive or productive, arising in this location should always be regarded with the gravest suspicion, while lesions occurring in the mid-portion of a long bone are likely not to be osteogenic sarcoma.

Osteolytic Osteogenic Sarcoma.—This tumor, the so-called malignant bone aneurysm of older writers, is an extremely vascular, almost purely destructive neoplasm which is highly malignant (Fig. 12). Although frequently described as being of medullary origin, it actually arises from the sub-cortical portion of the shaft, probably from the endosteum. It extends into the medulla, producing a central area of destruction, and early perforates the cortex and periosteum, infiltrating the adjacent tissues. The common locations are identical with those of the osteoblastic type, and the symptomatology consists of pain, swelling, loss of function, and pathologic fracture. There is commonly a history of some comparatively trivial trauma to which the symptoms are attributed. Local heat, slight elevation of temperature (99° to 101°), and a moderate leukocytosis (10,000 to 12,000) are common findings, frequently leading to an erroneous diagnosis of osteomyelitis. Even fluctuation of the tumor mass may be present, and in one of our cases a grayish fluid, apparently pus, was withdrawn by aspiration; the supposed pus, however, contained no bacteria. The tumor mass may become very large (Fig. 12). The following case history affords an example of the ease with which an erroneous diagnosis may be reached.

Fig. 12. See text.

Fig. 13. See text.

The patient was a girl, aged 14 years. Two months before admission, she ran two splinters into her left knee, and a minor infection followed. This was cared for by her mother, and the condition healed. Five weeks later a painful swelling of the knee developed. The patient was seen by an irregular practitioner who made x-ray films of the knee and diagnosed the condition as being osteomyelitis. No improvement followed treatment, and eight weeks

after the initial injury she was admitted to the Orthopedic Hospital. Her knee was hot, swollen, and tender, the swelling involving the knee and lower third of the thigh. *Fluctuation was present.* On aspiration there was obtained some pus (subsequently found to be sterile). Temperature was 100.6° F., pulse 90. Blood count was: red cells, 4,500,000; white cells, 11,400; 78 per cent polymorphonuclears, 1 per cent transitional, 2 per cent large lymphocytes, 19 per cent small lymphocytes. An x-ray examination demonstrated osteogenic sarcoma with metastases to the pelvis. The patient died in eleven months.

The x-ray findings are somewhat confusing, and diagnosis is often very difficult, the most common error being that of confusing this malignant newgrowth with benign giant-cell tumor. The important diagnostic points are: the almost purely destructive nature of the growth; its location at the ends of long bones, notably the lower end of the femur, the upper end of the tibia, and the upper end of the humerus; the lack of expansion of the shaft; the early and extensive destruction of the cortex, and the invasion of the soft tissues. Periosteal reaction will be present. It should be remembered that *benign tumors always expand the shaft,* breaking through the cortex only after the expansion has produced a paper-thinness; *that they tend to be symmetrical, and that they do not invade the soft tissues.*

Bone Cysts.—These are benign, localized, circumscribed, destructive lesions incapable of new bone formation excepting by way of repair following fracture. Generalized cystic degeneration of bone, such as is seen with parathyroid tumor and in osteitis fibrosa cystica, is not included in this discussion, which concerns itself only with solitary cysts. They occur in the metaphyseal portions of the shafts of long bones, the most common sites being in the upper end of the femur, the upper end of the tibia, and the upper one-third of the humerus. They may be present, of course, in any bone. They occur almost entirely during childhood, but since they very commonly cause no symptoms they may not be discovered until adult life. The symptomless bone cyst is often accidentally discovered; the so-called "latent cyst" is a cyst during this period of inactivity. Approximately one-half of all bone cysts are without symptoms, being discovered only when an x-ray examination is made following some injury. When present at all, the symptoms consist of slight pain or perhaps a limp. Bone cysts respond well to irradiation. The surgical treatment consists of curettage and the packing of the cavity with bone chips. There is a moderate tendency to recurrence.

There are eleven cases in our series, of which five were in the tibia, four in the femur, and one each in the humerus and fibula. The age varied from two to 19 years, the average age being twelve and a half years. One patient, aged two years, had three recurrences within three years.

On x-ray examination there is found a sharply limited area of decreased density, having well-defined outlines and with an absence of the normal markings of bone (Fig. 13). The cortex is intact unless the cyst is very large (in which case the cortex may be ruptured by mechanical pressure); the bone outline is normal unless the cyst has grown to such proportions as to expand it, in which case the cortex is very thin, and the enlargement is symmetrical. No new bone production is observed. Trabeculations may or may not be present. These tumors must be differentiated from solitary bone abscess, chondroma, myeloma, and the osteolytic form of osteogenic sarcoma. Solitary bone abscess is almost always found in the tibia, and is usually quite small. The periosteum may be elevated over the lesion. Chondroma is prone to occur in the hands and feet, but except for this difference in location differentiation from cyst is next to impossible. Myelomas and sarcomas have the general characteristics of malignant tumors, *i.e.*, lack of definite limiting walls, asymmetrical enlargement of the bone, early destruction of the cortex without expansion of the bone, and invasion of the soft tissues.

Giant-cell Tumors.—These are benign, essentially destructive newgrowths, producing new bone only after fracture, and very closely related to bone cysts. Indeed, it is quite probable that bone cysts and giant-cell tumors are merely variants of the same condition. The name "giant-cell sarcoma," formerly commonly used, and still heard rather frequently, is a misnomer, the tumor being in no sense a sarcoma, but a benign, non-metastasizing neoplasm with a moderate tendency to recur. Although largely a disease of adult life, these growths do occur in children. Of the eight cases in this series, six occurred in girls and two in boys. The age of admission varied from two to 19 years, the average age being 14 years. Half of these patients had had an injury and the tumor was found incidentally in the examination. Giant-cell tumors always arise in the region of an epiphysis; a newgrowth in the central portion of the shaft of a bone will not be a giant-cell tumor. The symptoms are moderate pain and swelling which may become very marked. The treatment depends somewhat on the location of the growth. Resection cures all cases, but is obviously so radical a treatment, accompanied by such severe multilation, that it is not justifiable for a benign tumor under ordinary conditions. Curettage, particularly when the cavity is filled with bone chips, is a satisfactory method of treatment, but somewhat less so than radiation therapy, which is the method of choice. Proper x-ray therapy will result in cure in about 75 per cent of cases, as compared with about 65 per cent of cures by surgical procedure (excluding resection).

The x-ray findings are rather typical. The giant-cell tumor is located at the epiphyseal end of a bone, asymmetrically placed, purely destructive, and expansile. The cortex becomes paper-thin, finally rupturing from the pressure, as distinguished from the erosive destruction without expansion characteristic of a malignant newgrowth. Trabeculæ are common, although these may disappear as the tumor becomes very large. The adjacent joint is seldom, if ever, involved. No periosteal reaction occurs, a point of great value in differentiation from malignant tumor (Fig. 14).

From time to time there appear in the literature reports of malignant giant-cell tumors, exhibiting metastases. A review of these cases seems to indicate diagnostic errors rather than variations in the behavior of true giant-cell tumors. In spite of these various reports it is likely that we should continue to regard these tumors as benign.

Codman reports a particular variety of giant-cell tumor, a so-called "chondromatous giant-cell tumor," which involves the upper epiphyseal lines and is limited by them. It, therefore, does not extend up to the articular cartilage, and in this it resembles a sarcoma. It lacks the characteristic trabeculæ, and is rather sharply demarcated. It is said to occur within the first two decades of life. We have not encountered a neoplasm of this description.

II. TUMORS ARISING FROM TISSUES RESIDENT IN BONE

Diffuse Endothelial Myeloma.—The diagnosis of "Ewing's tumor" is, of late, made more frequently than was formerly the case, and as our diagnostic acumen increases will be made still more frequently, as this is by no means a rare tumor. Its apparent comparative rarity is probably due largely to the fact that this neoplasm is commonly mistaken for either sarcoma or osteomyelitis, particularly the latter. Ewing's tumor is essentially a disease of childhood, although it is not extremely rare in adults. There are six cases in our series, of which five were in girls and one in a boy. The bones involved were the femur (two cases), the tibia, os calcis, ilium, and humerus (one case each). The ages of these patients ranged between five and 13 years, the average being ten years. Symptoms had existed for periods varying from six weeks to six months. All had been treated by diet, massage and baking, chiropractic, casts, or operation. *In all cases the working diagnosis was osteomyelitis.*

The x-ray findings are not particularly

characteristic (except with involvement of the shaft of a long bone, which produces fairly regular findings), and vary with the kind of bone involved, and, to some extent, with the location in the bone.

(*a*) *Ewing's Tumor of Long Bones.*—The earliest change which may be observed is a slight increase in the density of the medullary cavity. This is followed by periosteal reaction which results in the formation of thin layers of density parallel to the long axis of the shaft, the so-called "onion-skin" appearance (Fig. 15). Irregular areas of decreased and increased density appear in the cortical substance, and expansion begins, assuming an elliptical shape. These irregular areas of increased or decreased density represent areas of destruction and of replacement of bone by small masses of compact tumor tissue which is of greater density than the surrounding bone. At the point of reflection of the periosteum from the uninvolved portion of the shaft, some calcification occurs, producing the "lipping" so commonly described as a characteristic of bone sarcoma. At this point in the development of the tumor, the bone begins to exhibit a "moth-eaten" appearance, although it is difficult to demonstrate any definite breaking down of the cortex. In one case in which, after autopsy, the pathologist described the tumor as a reticulo-endothelioma (Fig. 16), the x-ray findings were quite different, the growth being purely osteolytic with no periosteal reaction, and with only an apparently homogeneous area of destruction visible in the roentgenograms. Such a variant must be given some consideration before Ewing's tumor may be excluded in differential diagnosis.

When the irregular or flat bones are in-

Fig. 14. See text.

Fig. 15. See text.

volved, the whole picture changes and the findings are quite different. An irregular and increasing sclerosis (or rather, appearance of sclerosis) develops, leading, in one of our cases, to the diagnosis of "sclerosing type of osteomyelitis" (Fig. 17). The bone was mottled, with small, rather well defined areas of increased density, while the bone as a whole (the os calcis) retained its normal size and shape. No definite breaking down of the cortex could be recognized. In another case, with the growth arising in the ilium (Fig. 18), a somewhat similar appearance was noted, but with what appeared to be fibrous strands passing through the involved area, with an appearance not unlike that observed in osteitis fibrosa. Later, this growth invaded the sacro-iliac synchondroses and the sacrum.

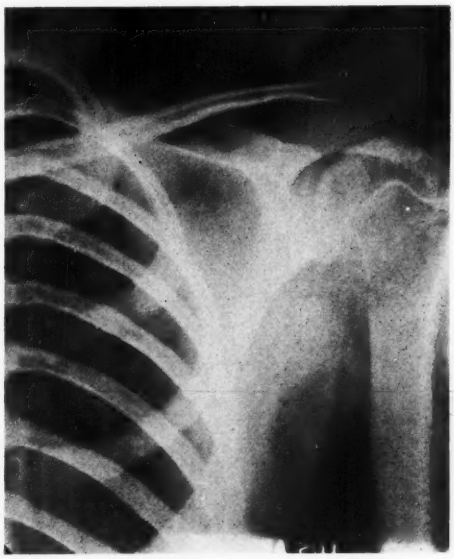


Fig. 16. See text.

Fig. 17. See text.

Fig. 18. See text.

The common symptoms are pain and swelling. In children, a mass is usually felt but not commonly in adults. Pain is at first moderate and transient, becoming very severe as the tumor grows, and ceasing when the growth has broken through the bony cortex. After an interval of freedom from pain, it usually begins again and continues until death or amputation. Moderate elevation of temperature is common, ranging from 99° to 103.4°, usually from 100° to 101°. Local redness and swelling, with increased local heat, are regular findings, and there is ordinarily a leukocytosis of from 10,000 to 14,000 white cells. A significant diagnostic point is that the increase is principally in the lymphocytes, the polymorphonuclear cells remaining unchanged. Nearly all cases have a history of injury. Just what significance should be attached to this is doubtful. The disease is essentially one of childhood, and children injure themselves constantly. The injury, therefore, may easily be coincidental. Moreover, it is quite possible that a trivial

injury which would ordinarily pass unnoticed may mark the beginning of pain in a tumor and so be closely connected with the growth in the minds of both patient and physician. There seems to be no really sound reason for believing these tumors to be related to trauma.

The principal diagnostic error is in confusing Ewing's tumor with osteomyelitis, an error which occurs so regularly as to be the rule. Differentiation is, in fact, difficult, sometimes even with biopsy.

The important differential points are the following:

Ewing's Tumor	Osteomyelitis
Temperature	
Usually 99° to 100°, may go higher: as high as 103.9° in one case	High—102° to 105°
Leukocyte count	
9,000 to 11,000, rarely higher	10,000 to 15,000 or higher
Differential count	
Polymorphonuclear cells—normal or decreased	Polymorphonuclear count—increased
Lymphocytes—increased	
X-ray findings	
Appear early	No demonstrable early changes
X-ray treatment	
Followed by improvement promptly	No change in symptoms
Aspiration biopsy	
May enable positive diagnosis	
Sequestrum	
Absent	Present—later
Periosteum	
Stripped, with "lipping" at point of reflection	Intact, unless broken through as window for pus drainage.

Two short case histories will well illustrate the difficulties encountered in the diagnosis of this neoplasm.

A girl, aged 14 years, was admitted for lameness in the left foot. Examination showed a swollen, red, hot, tense heel, extremely tender, which caused constant pain. Blood count: 5,000,000 red cells, 12,600 white, with 72 per cent polymorphonuclear cells, 8 per cent large lymphocytes, and 20 per cent small lymphocytes. On the next day the white count was 13,400, and on the following day 16,050. X-ray examination (Fig. 17) showed an apparent sclerosing process, with the cortex intact. Clinical diagnosis was osteomyelitis, sclerosing type. At operation, the bone was found to be hard and indurated, and filled with grayish "pus" and soft gelatinous material. Culture showed the "pus" to be sterile, and tissue section established the diagnosis of Ewing's tumor. The pain and swelling were relieved promptly by x-ray therapy, but the patient died three months later with widespread metastases.

A girl, aged 11 years, was admitted complaining of a painful left hip of six months' duration. Examination showed local heat, redness, and swelling of the left hip and left iliac region. The temperature ranged between 99° and 103.4° F.; the pulse was from 90 to 150. The blood count showed 3,900,000 red cells, and 14,400 white cells of which 84 per cent were polymorphonuclears, 14 per cent small lymphocytes, and 2 per cent transitionals. One week later the red cell count was 3,250,000, white cells 12,700. Clinical diagnosis was infectious osteitis with cystic changes. At operation yellowish "pus" was found, with much brownish-yellow gelatinous material in the bone. The x-ray findings (Fig. 18) closely resembled those of the case described above. The "pus" was sterile. Tissue sections showed typical Ewing's tumor. Response to x-ray therapy was prompt and gratifying, but death from widespread metastases followed in three months.

These two cases are cited, not because they are at all remarkable, but as an example of the errors one may so easily fall into, and as an illustration of the findings that so well explain the errors. Bloodgood's rule should always be remembered. It is that, in the presence of a destructive bone lesion not known positively to be inflammatory, consider the lesion as malignant and irradiate it. Had this rule been followed in the two cases cited, the prompt relief which followed would have served as a deciding diagnostic factor. To be particularly noted is the occurrence and the degree of temperature and leukocytosis, both of which simulate the findings expected in osteomyelitis. The history of the case is of the utmost importance. Biopsy should be made in every suspected case, preferably by the aspira-

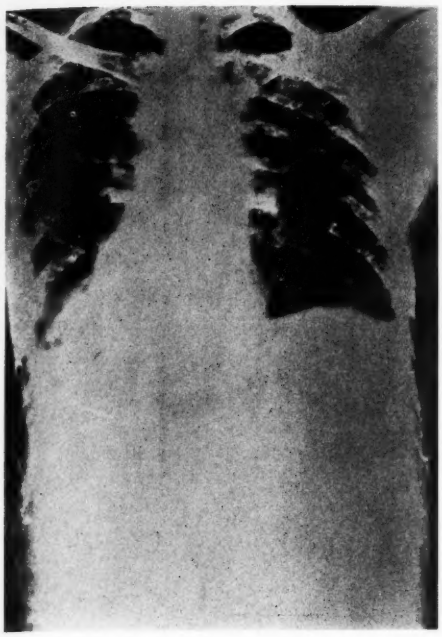


Fig. 19. See text.

tion method. Under no circumstances should surgical interference with the tumor itself be attempted. These tumors are extremely sensitive to irradiation, which is probably the method of choice. Certainly the disappearance of the tumor can be effected as readily as by amputation, and, of course, without mutilation. Unfortunately, metastases are prone to occur early and the subsidence of the tumor is not tantamount to cure of the patient. Several cases have been reported as living and symptom-free four or more years after amputation.

Myeloma.—It is very doubtful that this lesion occurs in children. We have encountered no cases of it, and reference to the literature offers no very convincing evidence of its occurrence. Although essentially a disease of later life, it occurs occasionally in young adults. A few cases of single myeloma have been reported, but they are not extremely well authenticated, and may well represent diagnostic errors. Whether or not such cases do occur, the fact remains that the characteristic form

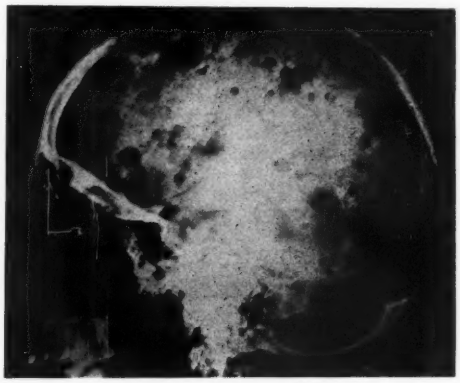


Fig. 20. See text.

of the disease exhibits many tumors, representing multiple myeloma. It is a very rare tumor, Geschickter and Copeland placing its incidence at 0.03 per cent of malignancies. The characteristic locations are the ribs, sternum, spine, clavicles, and pelvis (Fig. 19). Involvement of the skull (Fig. 20) is not infrequent, and when present is quite characteristic in its x-ray findings. The number of tumors present is very great, and the growths vary in size from a pinhead upward: most of them will be between 0.5 and 1.5 centimeter in diameter. Pathologic fracture occurs, but is surprisingly infrequent when the extent of bone involvement is considered. Sometimes one sees a vertebra so filled with myeloma that it casts a sort of "ghost shadow" in the roentgenogram but without alteration in its outline and with no compression present. The predominating symptom is pain, trivial at first, but becoming agonizing—probably more severe than that occurring in any other tumor. Involvement of the spine may be followed by paraplegia resulting from compression of the cord by tumor masses. Loss of weight, cachexia, and debility are of regular occurrence. A classical finding is the presence of the Bence-Jones bodies in the urine. It must be remembered, however, that they do not appear in every case, and that they are sometimes present from various causes. Metastasis to other organs occurs, although not regularly. There are no characteristic

blood changes; anemia is common, as might be expected. The x-ray findings are fairly characteristic. The location of the tumors in the ribs, sternum, or spine at once suggests myeloma. The pelvis and skull are not infrequently involved, and the long bones may also be affected. The characteristic lesion is a punched-out area of destruction, with no effort at production demonstrable. The number of tumors present in a given bone may produce a mottled appearance, and they frequently become confluent. In the vertebræ, there may be collapse and kyphos, or the vertebral body may retain its contour without deformity. The skull, when involved, exhibits multiple punched-out areas of destruction, commonly in the anterior portion of the skull. The treatment is purely symptomatic and palliative. X-ray therapy, although not curative, has great palliative value and should always be employed.

Fig. 21. See text.

Fig. 22. See text.

Fibrosarcomas and neurosarcomas are rare tumors. Only one occurs in this series, and because of its rarity, is described in detail. Properly speaking, these new-growths are not bone tumors, but are neoplasms of fibrous or nerve tissue which invade bone. The typical complaint is of pain of rather long duration, swelling, and decreased function of the part. The x-ray findings are not at all characteristic, consisting largely of bony destruction from without inward, and usually with a visible mass. Diagnosis is very difficult, even when tissue sections are made.

Fibrosarcoma is of a low degree of malignancy and the percentage of five-year cures following amputation is very high. These tumors are not very sensitive to irradiation, but when they involve a part not amenable to amputation, local excision and irradiation therapy will serve to prolong life.

The neurosarcomas are highly malignant,

are very insensitive to irradiation, and the percentage of cures is extremely low.

The extreme difficulty of correctly diagnosing a fibrosarcoma is illustrated by the following case history.

A boy, aged seven years, was admitted complaining of a growth in his right forearm, present for six months. Three years previously he had thrust his right forearm and hand into an electric wringer, but x-ray examination revealed no fracture. When last seen in the posture clinic of the hospital, one year before admission, no newgrowth was present in the right forearm. Examination showed a hard mass measuring 1 × 4 cm. in the flexor surface of the right forearm on the radial side. There were numerous dilated veins overlying the mass, and a flexion contracture was beginning. X-ray examination showed a productive lesion involving the radius, with no definite bone destruction (Fig. 21). Biopsy was performed and the pathologist's opinion was that the growth was a benign fibroma.

The tumor was excised, and recovery was uneventful. Two years later the child returned with a recurrence.

The majority of the staff believed the tumor to be, or to have become, malignant, but as there was a diversity of opinion sections and roentgenograms were submitted to several authorities.

Bloodgood and Willis Campbell thought that the tumor was benign; Crowell, Codman, and Geschickter held that it was malignant. Under x-ray therapy, about 25 per cent reduction in the size of the mass was secured. The total time now elapsed is six years since the occurrence of the tumor, and although its exact nature is still in doubt, the clinical course (the child is in good health) makes it likely that the tumor is non-malignant in character.

This case is cited only to show how completely even extraordinarily competent men may disagree in diagnosis, and how difficult the exact classification of certain tumors becomes.

III. TUMORS METASTASIZING TO BONE

Since this discussion is concerned only with primary tumors, Group III will not be considered here.

CLINICAL EXAMINATION

(*1*) *History.*—It is almost impossible to lay too much stress on the value of a proper history, but unhappily no phase of case study is so regularly slighted. It seems trite to point out that a hard swelling which has been present for several years is very unlikely to be a malignant tumor, or that a hot, red, swollen, painful, and tender leg of one week's duration is apt to be an inflammatory lesion; yet these elementary observations are all too frequently not made. Inquiry should be made into the age and occupation of the patient, since certain tumors have a predilection for certain age-groups. Is there anything suggestive in the family history? Have there been recurrent attacks of pain or swelling? Has the patient lived elsewhere (*e.g.*, in the tropics), and, if so, where? What diseases has the patient had? Are the parents syphilitic? Inquiries of this nature will naturally suggest themselves to the careful examiner. The investigation of the present complaint must include not only the manifest symptoms, but the character of their onset; the time of onset; the history of trauma, if any; the method of progression of the symptoms; the character of the pain, and such variations as increased pain at night. Inquiries at first sight unrelated must be made: as to chest symptoms, such as cough; abdominal symptoms, as diarrhea, melena, etc., since such findings may be the first clue to the metastatic lesions of malignancy. Has the patient had related symptoms previously? Are there any past injuries? Are the present symptoms new or are they a reappearance of previous symptoms?

(*2*) *Examination.*—This should not be limited to a perfunctory inspection and palpation of the affected part, but must be complete. Are there nodules in the scalp or in the calvarium? Are the eye move-

ments normal? Is exophthalmos present? (Remember that bone tumors can as well occur in the skull, and particularly the orbit, as elsewhere.) Examine the neck for palpable glands, remembering the so-called "sentinel gland" in the left neck. Examine the chest and the abdomen, bearing in mind that a primary tumor is occasionally located or identified only by finding metastases. The spine must be examined for kyphos, muscle spasm, areas of rigidity, contour, and the presence of tender points. Rectal examination should be made if any masses can be felt or are suspected in the pelvis. Finally, the affected part is to be examined, noting the location and character of the swelling, local heat, redness, tenderness, crepitation, hardness, irregularity, and fluctuation. Is the swelling symmetrical or one-sided? Is it a spherical mass or fusiform? Is motion of an adjacent joint interfered with? If so, may passive motion be performed? Are the reflexes normal?

Fig. 23. See text.

Fig. 24. See text.

(3) Tissue Examination.—Biopsy by the aspiration method may be performed safely, and usually satisfactorily. An attempt should be made to secure tissue from several planes of the growth. Open biopsy should be performed only between two tourniquets, preferably with an electrosurgical cutting unit, and the surgeon should be prepared to perform amputation if, after frozen section, malignant disease is revealed.

(4) Roentgen Differentiation.—The recognition of a bone tumor and its subsequent classification constitute an enormous diagnostic problem which may not be solved by roentgenologic examination alone. The clinical history, the symptoms, the physical findings, and a tissue examination are essential to a complete and proper diagnosis. Nevertheless, the x-ray examination is an extremely important factor; probably the most important single factor of the entire diagnostic procedure. Because of the infinite number of variations that may be present in a tumor it is impossible to recognize these growths by their characteristic x-ray appearances, or by mental comparison with some other known tumor, and all attempts at classification by such methods are inevitably doomed to failure. The first requirement for the roentgen differentiation of a bone tumor is a simple, logical plan of analysis of the tumor. The method here presented is by no means

an infallible one of making a diagnosis. Many times it will be impossible to establish one or more of the necessary points, but

Fig. 25. See text.

as a sort of schematic outline of procedure it has some merit.

There are only two possible changes in bone which may be recognized by roentgen examination, *viz.:* bone destruction and bone production, and all changes in the structure of bone consist of one or both of these changes. Since certain bone tumors, *e.g.*, osteomas, are purely productive growths, and since certain other newgrowths, *e.g.*, cysts, are purely destructive growths, it follows that a newgrowth of bone which is purely productive cannot be a cyst. Hence the first point to consider in the analysis of bone tumor is whether the process is a destructive one, a productive one, or represents a combination of these two changes.

The purely destructive bone tumors are:

Metastatic carcinoma
Multiple myeloma
Endothelioma
(*a*) Diffuse endothelial myeloma (Ewing's tumor)
(*b*) Reticulo-endothelioma
Certain types of osteogenic sarcoma
Chondrosarcoma
Bone cysts and giant-cell tumors, except after fracture.

If we now commence the analysis of a rather simple newgrowth of bone (Fig. 1), we find that the changes present consist of over-production of bone tissue. Since carcinoma, for example, is composed of epithelial tissue and is incapable of bone production, the tumor obviously cannot be carcinoma. In a like manner (that is, by eliminating those tumors which do not produce bone), all of the tumors of the above group may be excluded except osteogenic sarcoma. Thus by application of a single point the exclusion from consideration of a group of bone tumors has been accomplished.

The productive bone tumors are:

Osteoma
Osteochondroma
Certain types of osteogenic sarcoma
Chondromyxosarcoma
Cysts and giant-cell tumors after fracture.

It is important to distinguish between bone production and simple calcification, on one hand, and between bone destruction and the presence of translucent areas (Fig. 22), on the other. One must also remember to distinguish between destruction of bone by intrinsic process and bone destruction by extrinsic lesion pressure (Fig. 23), and between bone production and the replacement of bone by masses of tumor tissue of great density (Fig. 24).

One may, of course, find bone destruction and bone production in a single

lesion, as in many of the osteogenic sarcomas (Fig. 11).

We have now established a single point, *viz.:* the productive or destructive nature of the tumor as a method of approach to the analysis of the tumor and may proceed with the consideration of a second point: Does the tumor originate in the medulla or the cortex of the bone? Tumors arising from the cortex of the bone are:

Osteomas
Osteochondromas
Some of the sarcoma group, including chondrosarcomas and chondromyxosarcomas
Cysts (rarely)

Chondrosarcoma and chondromyxosarcoma may simulate medullary origin, although they are actually of peripheral origin.

Tumors originating in the medulla are:

Carcinomas and other metastatic newgrowths
Myelomas
Chondromas
Cysts
Giant-cell tumors and some of the sarcoma group.

If we now return to the original example (Fig. 1) which was found to be a productive tumor, and note that it arises from the cortex of the bone, we will have limited the possibility of differentiation to osteoma and osteochondroma. A growth arising in the cortex could not be carcinoma, since the circulatory mechanism bears the metastases to the medulla. Since cysts rarely originate in the cortex, a growth arising there is very probably not a cyst. Reasoning along these lines may be carried on until a group of possible tumors has been narrowed down to a much smaller field of possibility. Of course, the exact origin of a newgrowth is not always easily determined; when possible, more strength has been added to the diagnostic structure.

The third point of analytical approach is the condition of the cortex: is it intact or has it been destroyed? If there is cortical destruction, is it because the growth has ruptured it mechanically, by its sheer size, or has the cortex been eroded without expansion? Benign tumors, because of their slow growth, expand the shaft of the bone but do not perforate the cortex until they do so by simple pressure; malignant tumors grow rapidly and erode the cortex very early.

The fourth point for consideration is the presence or absence of invasion of the soft tissue. Remember that although benign tumors may displace tissue they never invade it, while all malignant tumors invade adjacent tissue.

By way of illustration we may now apply this method to the differentiation of the tumor shown in Figure 25. This is purely a destructive tumor originating in the medulla of a phalanx, with marked expansion of the cortex and cortical rupture. There is no evidence of new bone production and no invasion of the soft tissue. The purely destructive tumors are:

Cysts and giant-cell tumors
Carcinoma
Myeloma
Chondroma and some of the sarcomas.

Although the cortex of this phalanx is ruptured it has not been eroded and the tumor broke through it only after the cortex had expanded to paper-like thinness. The absence of any invasive changes eliminates the malignant tumors. The phalanges are a favorite site of multiple chondromas and classification of this tumor as chondroma would be supported by the presence of a similar tumor in the middle phalanx of the same finger. Any tumor may be analyzed in a like manner, although the solution of the problem is not always so readily found.

CONCLUSIONS

(1) Primary bone tumors are common in children, and are, indeed, probably essentially lesions of childhood.

(2) They occur most frequently in the regions of bone when growth is most intense, and at the chronological age when growth is most rapid.

(3) The findings in 117 cases of bone tumors in children have been described, and the treatment employed at the Orthopedic Hospital has been indicated.

ASBESTOSIS: A ROENTGENOLOGIC REVIEW OF 71 CASES

By J. RUSH SHULL, M.D., *Charlotte, N. C.*

ASBESTOS has been used in industry for centuries. It would seem that the pathologic action of this dust in the lungs would have been recognized before 1900, when Murray, in England, performed an autopsy on such a case. This autopsy was performed on a man, the last of 11 men who had begun work together in an asbestos plant in 1890. Murray did not report his findings until 1906. Probably the first case in English medical literature to be definitely proved as asbestosis, was reported by Cooke in 1924. This patient had tuberculosis as a complication.

Little attention has been paid to this form of pneumonoconiosis in the American literature until 1928, when the "Journal of the American Medical Association" commented editorially on Cooke's report and suggested that this condition deserved more consideration than it has been given. The first case reported in America was by Mills, in 1930. Since then many individual case reports, or small groups of cases, have been brought to our attention; but no large series from which a comprehensive study can be made has appeared.

Asbestosis may be defined as a disease of the lungs caused by the inhalation of asbestos dust and fiber. It is classified as a pneumonoconiosis and is characterized roentgenologically by an early interstitial fibrosis with progression into a terminal diffuse fibrosis. This fibrosis begins primarily in the bases of the lungs, involving the peribronchial structures. The parenchyma of the lungs is comparatively uninvolved. As the disease progresses there develops a filmy, hazy appearance of the lung-fields which has been aptly described as a "ground-glass appearance." The right side of the heart is frequently enlarged in

TABLE I.—PULMONARY ASBESTOSIS

Percentage of Cases Having	16 Slightly Advanced	35 Moderately Advanced	20 Markedly Advanced
Right-sided cardiac hypertrophy	37.5	62.8	95.0
Pericardial and pleural thickening	0	28.6	45.0
High left diaphragm	12.5	48.6	80.0
Emphysematous type of chest	6.3	65.7	95.0

CHART I.—PULMONARY ASBESTOSIS: SLIGHTLY ADVANCED CASES

	Name	Age	Color	Sex	Years' Exposure	Tuberculosis Present	Cardiac Hypertrophy Right-sided	Pericardial and Pleural Thickening	High Left Diaphragm	Trachea Displaced	Emphysematous Type of Chest	Comments
1	W. I. W.	28	W	M	4	–	Slight	–	+	–	–	No. 12, R. L. D., died of pneumonia 15 months after examination. Ill only three days.
2	C. W.*	34	W	M	2½	–	–	–	–	–	–	
3	S. E. T.	25	W	M	2½	–	–	–	–	–	–	
4	J. S.*	24	W	M		+	–	–	–	–	–	
5	B. B. R.	28	W	M	4	–	–	–	–	–	–	
6	K. T.*	26	W	M	2	+**	–	–	–	–	–	
7	L. B. H.*	26	W	M	9	+	–	–	–	–	–	
8	J. H.*	24	W	M	1½	–	Moderate	–	–	–	–	
9	J. G.	44	W	M	10	–	Moderate	–	+	–	Yes	
10	J. L. E.*	49	W	M	6	–	–	–	–	–	–	
11	W. F.	38	W	F	13	–	–	–	–	–	–	
12	R. L. D.	46	W	M	12	–	Slight	–	–	–	–	
13	T. J. C.*	36	W	M	8	–	Slight	–	–	–	–	
14	L. E. B.	34	W	M	2½	–	–	–	–	–	–	
15	L. M.	23	W	F	4	–	–	–	–	–	–	
16	C. B. J.	30	W	M	5	–	Slight	–	–	–	–	

* Re-examined 15 months later.
** Healed miliary.

the moderately advanced cases, and it is a common finding in the markedly advanced cases. The fibrosis is a result of chemical irritation caused by silica in the dust and of mechanical irritation instigated by the asbestos fibers.

Another finding characteristic of this disease is the presence of peculiar golden colored, crustation-like bodies in the lungs of these patients. Stewart and Stewart and Haddow have suggested the name "asbestos bodies" for them. Gloyne described a technic whereby the central core of these bodies was found to be a minute asbestos fiber. He also pointed out that it is important to demonstrate tubercle bacilli before one can assume that tuberculosis is a complicating factor.

Clinically, the most striking symptom is undoubtedly dyspnea. This is progressive, slow, and insidious in development and is due to inelasticity of the lungs and interference with blood supply. Cough and expectoration, especially the latter, may be nearly or quite absent except during bronchitic attacks. Anorexia, cyanosis, loss of weight, and emaciation are rather late manifestations, and are usually out of proportion to the physical signs, differing thereby from tuberculosis alone.

During the latter part of 1934 it was my privilege to examine the chests of 71 of 100 workers who had been dismissed from local asbestos plants. All had undergone physical examination before they were referred for roentgenologic study and were found to be physically disabled.

Stereoroentgenograms were made of each

CHART II.—PULMONARY ASBESTOSIS: MODERATELY ADVANCED CASES

	Name	Age	Color	Sex	Years' Exposure	Tuberculosis Present	Cardiac Hypertrophy Right-sided	Pericardial and Pleural Thickening	High Left Diaphragm	Trachea Displaced	Emphysematous Type of Chest	Comments
1	R. A. W.*	26	W	M	5	–	–	–	–	–	Yes	
2	L. E. W.	25	W	M	7	++	–	–	–	R	Yes	No. 2, L. E. W., died one year after examination. Tuberculosis.
3	J. C. S.	36	W	M	8	–	Slight	–	–	–	–	
4	W. L. B.	30	W	M	15	–	Moderate	–	+	–	Yes	
5	C. A. S.*	53	W	M	8	–	Slight	Yes	+	–	Yes	
6	R. H. S.	57	W	M	5	–	–	Yes	–	–	Yes	
7	T. R.	40	C	M	5	–	–	–	+	–	Yes	
8	C. D.	33	W	M	9	–	Moderate	–	–	–	Yes	
9	J. M.	39	W	M	12	–	Moderate	Yes	+	–	–	
10	L. M.	41	W	F	7	–	Moderate	–	–	–	Yes	
11	C. M.	42	W	F	11	–	–	–	+	–	Yes	
12	O. B. L.	43	W	M	7	–	Slight	Yes	–	–	Yes	
13	R. K.*	39	W	M	10	–	–	–	–	–	–	
14	E. C. L.	23	W	M	3	–	Slight	–	–	–	–	
15	S. J.	31	C	M	7	–	Moderate	–	–	–	Yes	
16	M. I.*	37	W	M	9	+	–	Yes	–	–	–	
17	R. G. J.	38	W	M	12	++	Slight	Yes	+	L	–	No. 17, R. G. J., is in terminal stages of tuberculosis. Death imminent.
18	W. H.	24	W	M	4	–	Slight	–	+	–	–	
19	H. H.	20	W	M	1½	–	Moderate	–	+	–	Yes	
20	U. L. J.	38	W	M	10	–	–	–	+	–	Yes	
21	O. G.*	39	W	M	7	–	Moderate	–	+	–	Yes	
22	R. G.	27	C	M	7½	–	–	–	–	–	Yes	
23	P. F.	38	W	F	11	–	Slight	–	–	–	–	
24	L. F.	53	W	F	12	–	Moderate	Yes	–	R	–	
25	W. W. F.	40	W	M	10	–	Slight	–	–	–	–	
26	A. W.	40	C	M	1½	–	Advanced	Yes	+	R	Yes	
27	S. D.	29	C	M	6	–	–	–	+	–	Yes	
28	J. D.	30	W	M	6	–	Moderate	–	+	–	Yes	
29	F. C. C.*	39	W	M	8	+	–	Yes	+	–	–	
30	W. L. C.	42	W	M	6	–	Advanced	–	–	–	Yes	
31	V. O. B.	36	W	M	8	–	Slight	Yes	–	–	Yes	
32	A. R. B.	54	W	M	12	–	Slight	–	–	–	–	
33	G. L. B.	57	W	F	15	–	Moderate	–	+	–	Yes	
34	F. A. C.	28	W	M	8	–	–	–	+	–	Yes	
35	C. G.*	31	W	M	8	–	–	–	+	–	Yes	

* Re-examined 15 months later.

patient, using a skin-target distance of 72 inches. The same technic was meticulously observed in each case, so that films of good contrast and equal exposure could be obtained for comparison. A number were also examined roentgenoscopically. Fifty-six were white males, six were white females, and nine were negro males. The average age was 34.4 years and the time of exposure varied from 16 months to 21 years.

In eight recognized cases of tuberculosis

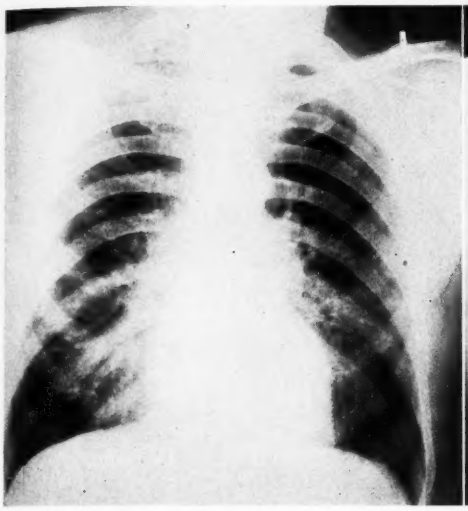


Fig. 1.

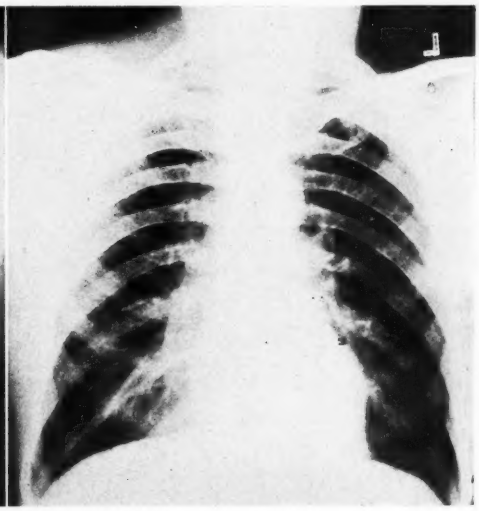


Fig. 2.

Fig. 1. Case 3756. Examined on Dec. 3, 1934; white male, aged 49 years. Patient was exposed six years; no complaints. Early type of asbestosis.
Fig. 2. Re-examination made on Feb. 15, 1936; there is slight improvement.

CHART III.—PULMONARY ASBESTOSIS: MARKEDLY ADVANCED CASES

	Name	Age	Color	Sex	Years' Exposure	Tuberculosis Present	Cardiac Hypertrophy Right-sided	Pericardial and Pleural Thickening	High Left Diaphragm	Trachea Displaced	Emphysematous Type of Chest	Comments
1	P. S.	36	W	M	10	–	Moderate	–	+	–	Yes	No. 3, S. G., died three months after examination, of an acute fulminating tuberculosis. Autopsy reported in text.
2	C. H. S.*	33	W	M	1½	–	Slight	+	–	–	Yes	
3	S. G.	30	C	M	8	–	Moderate	–	–	–	Yes	
4	R. W.	40	W	M	8	–	Slight	+	+	–	Yes	
5	P. J. V.	55	W	M	20	–	Advanced	+	+	–	Yes	
6	G. W. C.	38	W	M	13	–	Slight	–	+	R	Yes	
7	G. H.*	36	W	M	9	–	Moderate	+	+	–	Yes	No. 5, P. J. V., died one month after examination. Autopsy reported.
8	S. P.	36	W	M	6	–	Moderate	+	+	–	Yes	
9	E. A.	26	C	M	8	–	Moderate	+	+	–	Yes	
10	C. G.*	34	C	M	9	–	Moderate	–	+	–	Yes	
11	F. B.	31	W	M	6	–	Moderate	–	+	–	Yes	No. 6, G. W. C., is in sanatorium with tuberculosis.
12	L. B. J.*	35	W	M	8	–	Moderate	–	+	–	Yes	
13	C. Mc. N.	47	W	M	10	+	Slight	+	+	R	Yes	
14	T. F. E.	50	W	M	6	–	Moderate	–	+	–	Yes	
15	A. J. H.*	37	W	M	10	–	Moderate	+	+	–	Yes	
16	W. E. G.*	38	W	M	8	–	Slight	–	+	–	Yes	No. 16, W. E. G., had pneumonia four months after examination. Recovery.
17	R. H.*	41	C	M	12	–	Advanced	–	+	–	Yes	
18	G. M. C.	32	W	M	6	–	–	+	–	–	Yes	
19	F. D. B.	31	W	M	7	–	Slight	–	+	–	Yes	
20	G. C.	36	W	M	9	–	Moderate	–	–	–	–	

* Re-examined 15 months later.

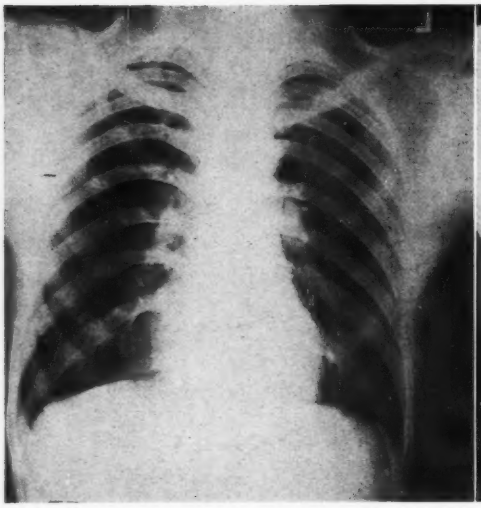


Fig. 3.

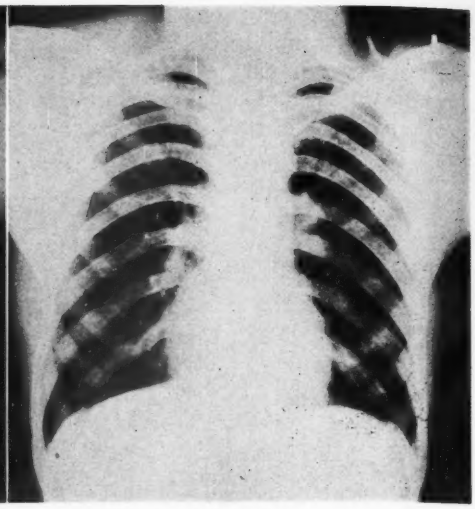


Fig. 4.

Fig. 3. Case 3744. Examined on Dec. 1, 1934; white male, aged 24 years. Patient was exposed two years. Only complaint was a slight cough for few months. Early type of asbestosis. Note slight prominence of right auricle.

Fig. 4. Re-examination made on Feb. 13, 1936. No complaints. There is definite increased aeration of the lung-fields.

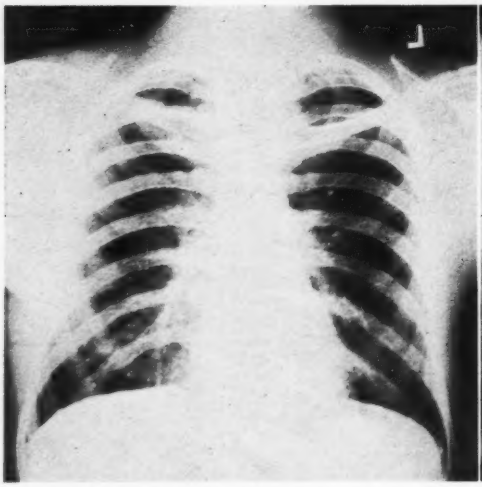


Fig. 5.

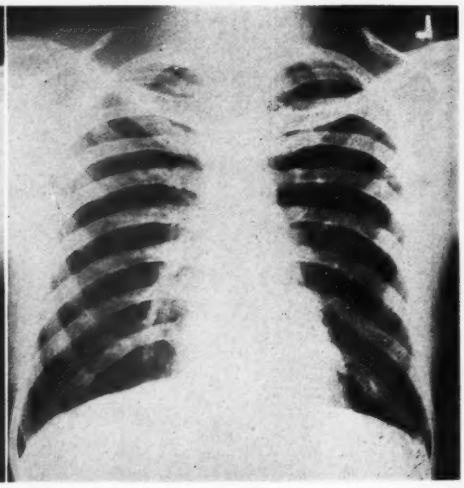


Fig. 6.

Fig. 5. Case 3699. Examined on Nov. 22, 1934; white male, aged 31 years. Patient was exposed five years. Early type of asbestosis with slight cough and dyspnea. Note characteristic basal involvement.

Fig. 6. Re-examination made on Feb. 13, 1936. No symptoms. Note decided roentgenologic improvement.

(11.3 per cent) in the entire series, the degree of infiltration was only slight to moderately advanced and one or both upper lobes were involved. Only two cases appeared active.

Since these examinations were made, five patients have died. Autopsy was performed on two, a detailed report of which will follow. Of the remaining 66 patients, 21 have been re-examined recently.

In studying the orignal and follow-up roentgenograms of the series and contrast-

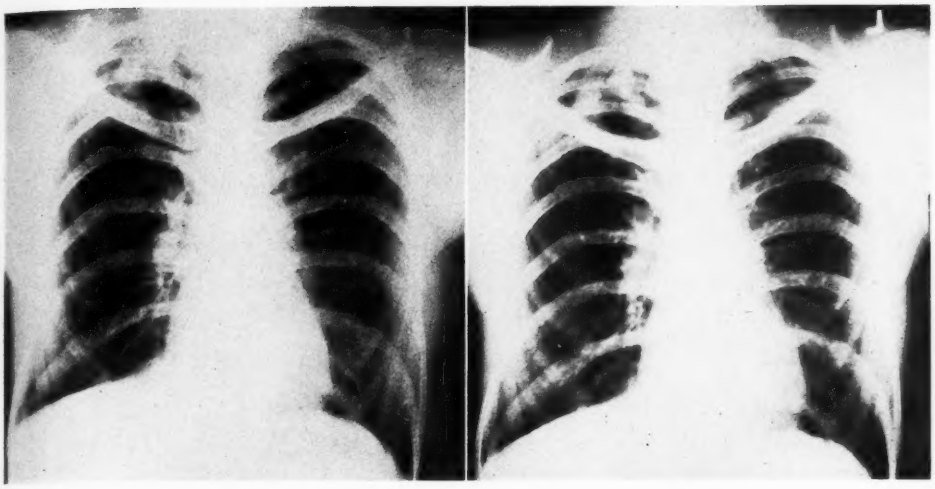


Fig. 7. Fig. 8.

Fig. 7. Case 3839. Examined on Jan. 7, 1935; white male, aged 37 years. Patient was exposed nine years. Slightly advanced type of asbestosis. Slight cough and some dyspnea, but no time loss from work. Note that in addition to the findings of asbestosis there is an active tuberculous lesion in the upper right lobe.

Fig. 8. Re-examination made on Feb. 15, 1936. Note improvement in lung-fields. No complaints. Decided gain in weight. Has worked steadily in a textile plant since discharge from asbestos mill in November, 1934.

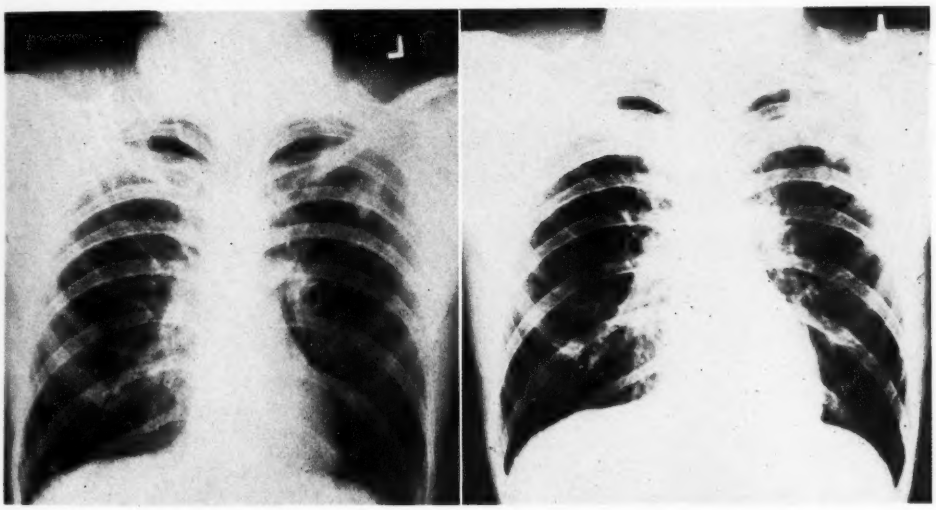


Fig. 9. Fig. 10.

Fig. 9. Case 3738. Examined on Dec. 1, 1934; white male, aged 26 years. Patient was exposed ten years. Slight cough for one year. Early type of asbestosis. Note co-existing tuberculosis.

Fig. 10. Re-examination made on Feb. 10, 1936. This patient has gained eight pounds in weight and has worked as a radio technician since his discharge from the asbestos mill in November, 1934. Note fibrosing of tuberculous lesion and increased aeration of lung-fields.

ing them with a number of plates of other types of pneumonoconiosis, it has been possible to make certain observations which seem to be peculiar to this group of asbestosis cases as a whole. These are tabulated under Table I.

Furthermore, it was obvious that a classification could be effected. Since the

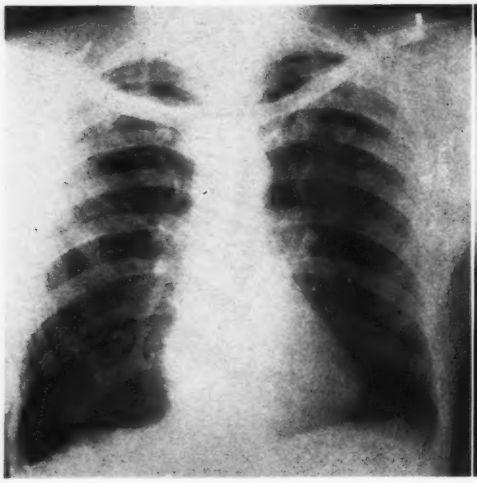


Fig. 11.

Fig. 12.

Fig. 11. Case 3771. Examined on Dec. 5, 1934; white male, aged 37 years. Patient was exposed eight years. Moderately advanced type of asbestosis. Note pericardial and pleural adhesions.
Fig. 12. Re-examination made on Feb. 28, 1936. No change in the appearance of the lung-fields.

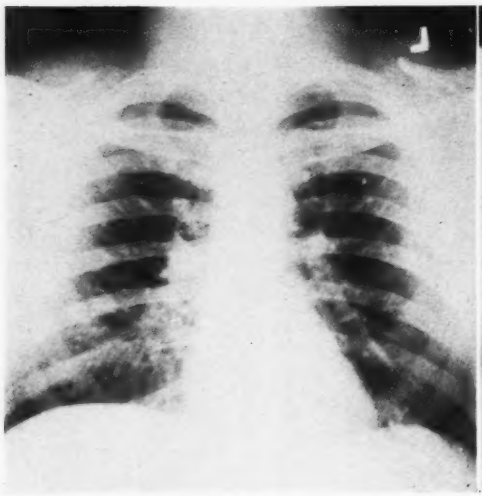


Fig. 13.

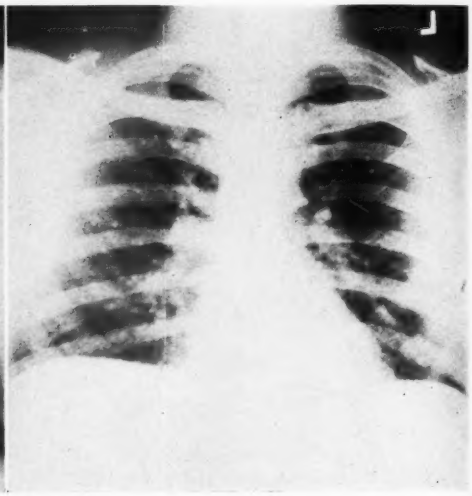


Fig. 14.

Fig. 13. Case 3755. Examined on Dec. 3, 1934; white male, aged 26 years. Patient was exposed two years. He had previously worked on a farm. Past medical history was entirely negative. Moderately advanced type of asbestosis. No subjective complaints. Note miliary-like deposits suggestive of a healed tuberculosis.
Fig. 14. Re-examination made on Feb. 22, 1936. Patient now regularly employed in a textile plant. No complaints. Note slight but definite increased aeration.

one constant feature of all these cases is unquestionably the diffuse fibrosis, this sign was taken as the "yard stick" in compiling such a classification. After the groupings were arranged, the other roentgenologic findings were tabulated under each group.

The following seems to be a satisfactory and working classification:

(1) Slightly advanced cases.
(2) Moderately advanced cases.
(3) Markedly advanced cases.

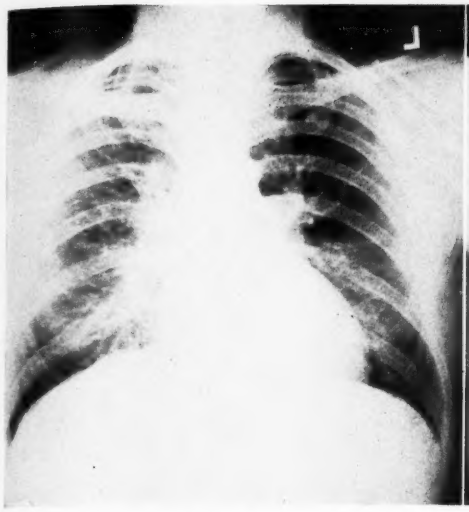


Fig. 15.

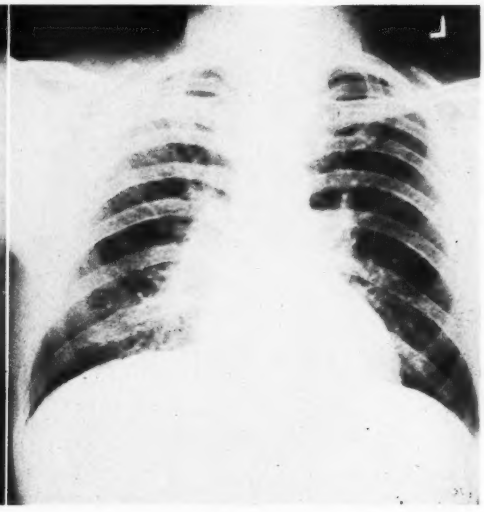


Fig. 16.

Fig. 15. Case 3708. Examined on Nov. 24, 1934; white male, aged 35 years. Patient was exposed seven years. Chief complaint was dyspnea. Moderately advanced type of asbestosis.
Fig. 16. Re-examination made on Feb. 17, 1936. There is a slight increase in aeration of the lung-fields.

Fig. 17.

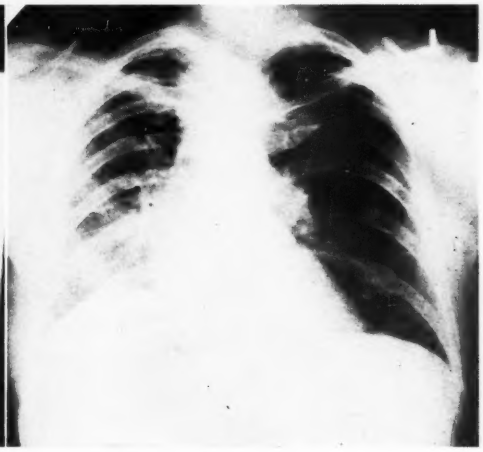
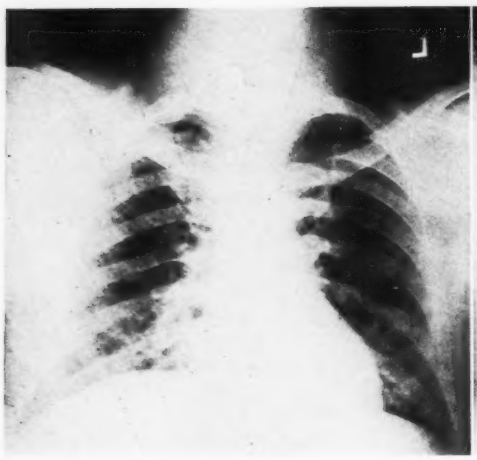


Fig. 18.

Fig. 17. Case 3743. Examined on Dec. 1, 1934; white male, aged 38 years. Patient was exposed eight years. Cough and dyspnea were the chief complaints. Markedly advanced type of asbestosis.
Fig. 18. Re-examination made on March 15, 1935. Patient had an attack of lobar pneumonia in January, 1935. Note changes in lung-fields and in cardiac outline.

1. *Slightly Advanced Cases* (Chart 1).—In this group are 16 cases. In all, there is a beginning interstitial fibrosis in both lung bases producing a filmy, hazy appearance. The roentgen film cannot be considered diagnostic; a history of exposure is necessary to aid in arriving at a diagnosis. There are no cases of pericardial and pleural thickening, in none is the trachea displaced, rarely is there an emphysematous type of chest, and less than half showed right-sided cardial hypertrophy. In this group there



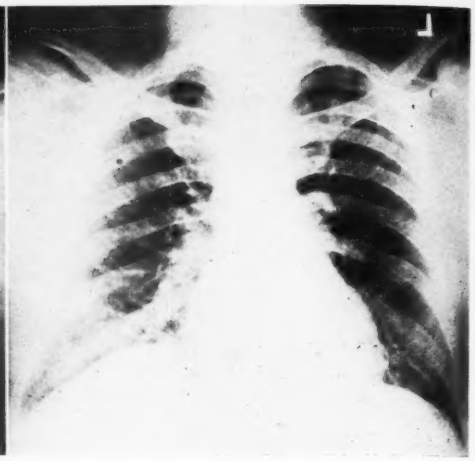


Fig. 19. Fig. 20.

Fig. 19. Case 3751. Examined on Dec. 3, 1934; white male, aged 33 years. Patient was exposed one and one-half years. He had cough for two months with moderate dyspnea. Markedly advanced type of pulmonary asbestosis.

Fig. 20. Re-examination made on Feb. 10, 1936; no improvement. Note slight increase in cardiac base. (This patient's father had worked in the same plant for five years prior to dismissal in September, 1934. His lungs showed only an early or slightly advanced type.)

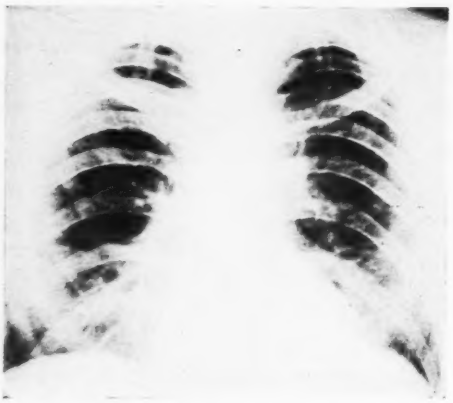


Fig. 21. Case 3735. Examined on Nov. 11, 1934; white male, aged 39 years. Patient was exposed seven years. Markedly advanced type of asbestosis. Dyspnea was marked. Note left diaphragm and characteristic basal involvement. This film is typical of markedly advanced asbestosis as evidenced by basal involvement, fuzzy cardiac outline, high left diaphragm, and the characteristic ground-glass appearance of the lung-fields.

are two females and 14 males, all white. The average age is 32.2 years and the average time of exposure is 5.4 years.

2. *Moderately Advanced Cases* (Chart 2).—There are 35 patients in this group. There is definite interstitial fibrosis radiating to the periphery and producing a ground-glass appearance to the lung-fields. Bronchiovascular markings are increased and pericardial and pleural thickening are noted. Right-sided cardiac enlargement is more frequent and emphysematous types of chests are common. The series contains five white females and 30 males, five of whom are colored. The average age is 37.1 years and the average time of exposure is 8 years.

3. *Markedly Advanced Cases* (Chart 3).—There are 20 patients in this group. In only one is there no roentgenologic evidence of right-sided cardiac hypertrophy and in only one other is evidence of an emphysematous type of chest lacking. Nearly half have pericardial and pleural thickening and the majority show a high left diaphragm (Table I). The average age in this group is 37.1 years and the average time of exposure 8.7 years. All are males, 16 white and four colored.

In the entire series only six showed evidence of slight displacement of the trachea,

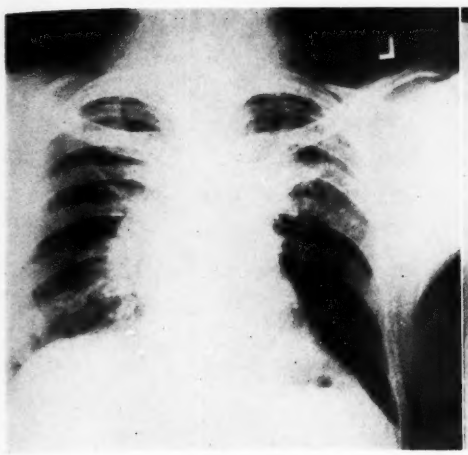


Fig. 22.

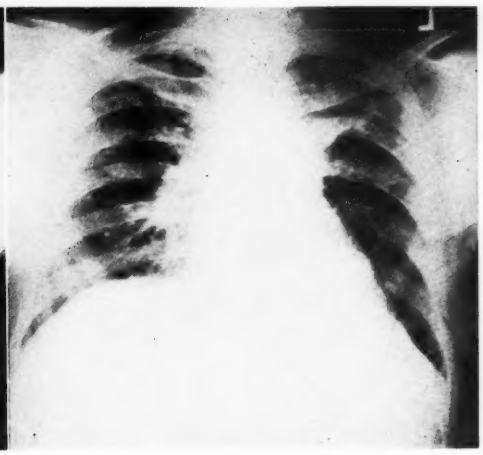


Fig. 23.

Fig. 22. Case 3700. Examined on Nov. 22, 1934; white male, aged 36 years. Patient was exposed ten years. He had an unproductive cough with a negative sputum. Note the shaggy heart. Markedly advanced type of pulmonary asbestosis.

Fig. 23. Re-examination made on Feb. 18, 1936. Chief complaint was dyspnea. Note spread of fibrosis.

and of these three had x-ray evidence of tuberculosis. As would be expected, the degree of cardiac hypertrophy is largely dependent on the length of exposure. Other findings do not seem to depend on this factor to the same extent. Just what influence the degree of exposure, *i.e.*, the type and amount of dust inhaled, exerts on the roentgenologic picture is difficult to say, as it was not possible to determine this factor. One would expect more serious and extensive pathologic changes in cases in which there has been a greater degree of exposure. Undoubtedly there are other factors which play an important rôle in the amount of damage done to lung tissue: the patient's constitutional make-up, his intelligence, previous disease of the lungs, and other causes may exert an influence in the rapidity with which the disease progresses. I do not believe tuberculosis plays a significant part in the development or prognosis of asbestosis. Roentgenologic evidence tends to uphold this statement. Two of the patients with definite evidence of tuberculosis showed unquestionable improvement on re-examination 15 months subsequently. Both are employed in other industries.

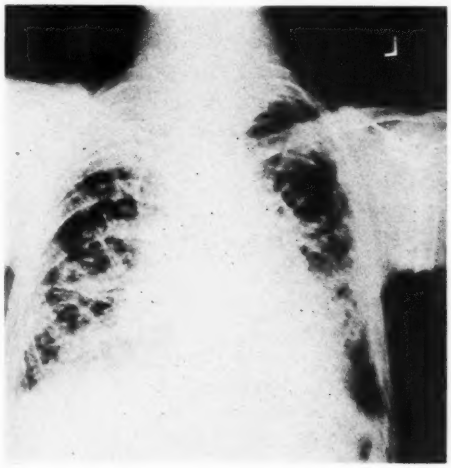


Fig. 24. See caption under Figures 25 and 26.

The series of re-examined patients is too small, and perhaps insufficient time has elapsed, to draw definite conclusions on the progress of the disease from a roentgenologic standpoint. When more patients have been re-examined over a longer period of time, such a report will appear. However, the observations made on the 21 re-examined patients are worthy of note.

Fig. 25.

Fig. 26.

Figs. 24, 25, and 26. Case 3792. Examined Dec. 12, 1934; white male, aged 55 years. Patient was exposed 25 years. He had been totally disabled for the past two years. Marked dyspnea, troublesome cough, emaciation, and peculiar palor of the skin. Markedly advanced type of asbestosis. Note the shaggy heart and very little air space remaining. This patient died one month after this examination. Photographs of lungs and summary of pathologic findings after autopsy are found in the text.

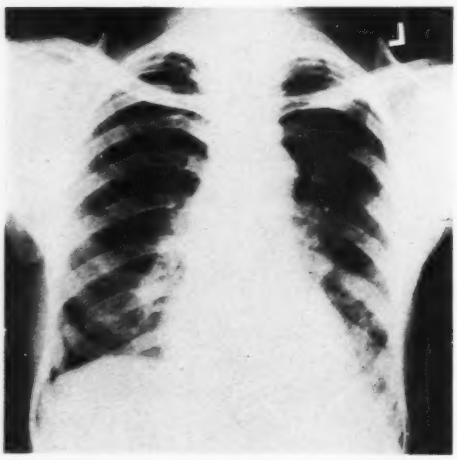


Fig. 27. Case 3746. Examined on Dec. 3, 1934; negro male, aged 30 years. Patient was exposed seven years. Chief complaint was cough of five years' duration and recent continued hemoptysis. There is some cardiac enlargement but no roentgenologic evidence of tuberculosis. He died three months later and at autopsy tuberculosis was found. (See report.)

In the Markedly Advanced Group there were five re-examinations: three gained some weight, one lost, and the other remained the same. One showed no change in the roentgen picture and in three there was an increase in the amount of fibrosis. There was no improvement in the heart shadow in two, and in two it had enlarged. Clinically four showed no improvement. The fifth (See Figs. 29 and 30) showed definite improvement.

In the Moderately Advanced Group, seven were re-examined. Three had gained a substantial amount of weight, two remained the same, and two had lost. Three showed improvement in the lung picture and two a definite spread of the disease. One showed an increase in the size of the heart and another showed definite improvement.

In the Slightly Advanced Group, nine were re-examined. Three had gained considerable weight and only one had lost. Five showed improvement in the lung picture and only one any increased fibrosis. In none was there any alteration in the size of the heart. Three of these cases had roentgen evidence of tuberculosis. Clinically these patients were much improved.

Generally speaking, it would seem that improvement can be expected in the early cases when they are removed from asbestos

plants. As the disease progresses, improvement is less likely, and when the condition becomes markedly advanced the patient usually becomes a permanent invalid and the prognosis must be considered entirely unfavorable. Lanza states: "It is by no means certain that asbestosis progresses as does silicosis after withdrawal from dust exposure, nor does infection seem to be as closely and intimately associated with asbestosis as with silicosis."

Fig. 28. Case 3746. Roentgenogram of lungs following autopsy. Lung mapping was attempted but was unsatisfactory. Synopsis of autopsy findings reported in text.

AUTOPSY FINDINGS IN ASBESTOSIS

Autopsy was performed on two patients in the Markedly Advanced Group. One (S. G.) died of an acute fulminating tuberculosis process, with continued hemaphysis, three months after examination. There was no roentgenologic evidence of this condition. The other (P. J. V.) died one month after examination, of asbestosis. Pathologic examinations of the lungs were made by Dr. J. B. Bullitt, Professor of Pathology in the School of Medicine at the University of North Carolina.

Case 1 (S. G.). "*Gross:* The lungs are somewhat distorted by being molded in the container. The conditions in the two lungs are essentially the same. The pleura over practically the whole surface is rough and apparently had been adherent to the parietes; in some areas it is as much as two millimeters thick. The interlobular divisions are obliterated by adhesions except as below described. The cut surfaces show nearly uniform character from base to apex, though the degree of damage is greater in the central and base portions. Narrow grayish lines block the tissue into irregular small areas. A few small gray spots, resembling tubercles, are scattered here and there from base to apex. Near the central portion of each lung is an irregular shaped area of solidification, about two by three centimeters, which is apparently caseous pneumonia. Similar areas of smaller size are found in the apical and in the basal portions. In this area are small cavities, about three or four millimeters in diameter. Except in these areas, the tissue has an elastic feel, similar to but somewhat less than that of normal lung. I find nothing to justify the massive hemorrhage that he is said to have had shortly before death. The heart showed nothing of import. The hilal lymph nodes are enlarged and mottled with caseous areas.

"*Microscopical:* In all parts of both lungs there is considerable fibrosis. In great part, this consists of small irregular shaped nodules with lobular distribution, but also there is much fine fibrosis thickening the walls of alveoli that are still functional. Most of this fibrosis looks like old healed scars, but much of it shows some infiltration with mononuclear cells, suggestive of a slowly progressive process. In practically all these scars there is some pigment deposit—in some places a considerable amount, and also there are numbers of fine asbestos shreds. I am confident that much of this fibrosis is due to the asbestos, though part of it might be healed tuberculosis. In addition to this asbestos, the mi-

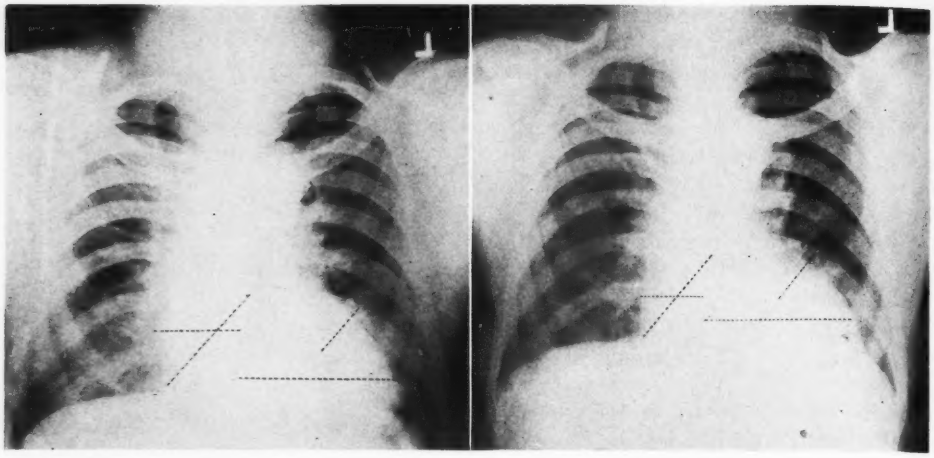


Fig. 29. Fig. 30.

Fig. 29. Case 3778. Examined on Nov. 4, 1934; negro male, aged 40 years. Patient was exposed 12 years. He had had cough and dyspnea for two years. Markedly advanced type of asbestosis with typical cardiac enlargement. Measurements: MR 5.5, ML 10.2, and Base 12.0.

Fig. 30. Re-examination made on Feb. 14, 1936. Note diminished cardiac outline and increased aeration of the lung-fields. Dyspnea now chief complaint, but not as marked as a year ago. Measurements: MR 4.5, ML 10.0, and Base 10.5.

This is the only case in the markedly advanced group that has shown any improvement clinically or roentgenologically.

croscope shows many very small typical tubercles in various parts of the lungs; moreover, the caseous areas mentioned above are characteristically tuberculous."

Case 2 (P. J. V.). "*Gross:* Both lungs are essentially alike. The interlobar clefts are obliterated by dense adhesions. The greater part of the pleural surfaces are roughened and appear to have been adherent to the parietes, though some areas are smooth and glistening and resemble the normal. From apex to base, on the cut surfaces, the tissue is blocked off into small polygonal areas by narrow white lines. In occasional places these lines broaden to as much as one to three millimeters; also at several places, just beneath the pleura, the pulmonary tissue is solidified into about five or six millimeters in thickness and twenty to thirty millimeters in breadth. Except for the fibrosis above described, the pulmonary tissue appears essentially normal to the naked eye, but when pinched between the fingers it has a distinctly increased density, especially in the lower lobes.

"The hilal lymph nodes are much enlarged and their cut surfaces are slightly mottled with gray.

"The heart is distinctly larger than the average normal. The right ventricle is dilated, probably sufficiently to prevent perfect competence of the valves. The muscle is pale and slightly streaked. It is apparently not quite as firm in texture as normal. The aorta and the heart valves show a moderate amount of atheroma.

"*Microscopical:* The microscope demonstrates an amount of fibrosis greatly in excess of what the naked eye would lead one to expect. This is more marked in the lower lobes but is present in all parts of both lungs. It consists of nodules and bands of connective tissue which have clearly resulted in the obliteration of much pulmonary tissue. Much of it consists of old, hard scars with no present inflammation, but in much of it the process seems

progressive, as indicated by a low grade exudate (mononuclear cells). The rubbery plaques on the pleural surfaces are partly made up of thickened pleura, but mostly of actual lung tissue obliterated by fibrous tissue. A good deal of pigment is present in most areas. In all areas there are numerous spicules of asbestos. Some of the scars in this lung might well pass for healed tubercles, but I find no present tubercles, and careful search fails to demonstrate any acid-fast bacilli in any area. The lymph nodes at the hilum show hyperplasia, some little fibrosis, a moderate amount of pigment, and a few spicules (very small) of asbestos, but no evidence of tuberculosis.

"Except for moderate atheroma, the aorta and heart show nothing of importance under the microscope."

ASBESTOSIS AND SILICOSIS

The roentgenographic picture of silicosis does not resemble asbestosis. In the former, the upper third of the lungs is involved and the fibrosis is parenchymal and not interstitial. The lung-fields show characteristic nodulation, and, in advanced cases, a coalescence producing dense opaque areas in contrast with the typical, hazy, ground-glass appearance of the asbestosis lung-fields. Silicosis is definitely a progressive disease, even when the patient has been removed from dust exposure. This is not the case in asbestosis, certainly in the slightly and moderately advanced groups. In asbestosis, there is a definite tendency to pleural and pericardial involvement which is strikingly absent in silicosis.

MEDICO-LEGAL STATUS OF ASBESTOSIS IN NORTH CAROLINA

Just a word about the status of asbestosis in North Carolina from a medico-legal standpoint. In the case of McNeely *vs.* Asbestos Co., 206 N. C., page 568, the State Supreme Court held the plaintiff suffered an "injury by accident." The Court said: "He alleged in his complaint and offered evidence tending to show that his injury was produced and proximately caused by negligence of the defendant in that it maintains no dusting or suction system such as is approved and in general use in other asbestos plants. Consequently his allegation and proof both established the fact that his injury was caused by the negligence of the employer and hence was not the usual incident or result of the particular employment in which the workman is engaged. That is to say, the injury was not produced by the inherent nature of the work itself and classifiable as an occupational disease, but was produced by the active negligence of the employer and his failure to exercise reasonable care." The Court held in effect that the injury itself was an accident in that it was an unlooked for and untoward event which was not expected or designed by the plaintiff, and therefore was compensable under the Compensation Act. As a consequence of this decision, the State Legislature of 1935 amended the Compensation Act to include twenty-five occupational diseases, including asbestosis.

CONCLUSIONS

1. Asbestosis is a definite disease entity.

2. Inhalation of air laden with asbestos dust and fibers produces characteristic changes in the lung.

3. The time required for the development of the disease is variable. The earliest patient in my series had worked in an asbestos mill only 16 months.

4. The disease *asbestosis* differs from the disease *silicosis*, clinically, pathologically, and roentgenologically.

5. While the roentgenogram is the most reliable diagnostic aid, the interpretation and correlation with clinical signs and symptoms is often difficult. Without the history of exposure a certain number of slightly advanced cases will not be recognized.

6. A fair percentage of the slightly advanced and the moderately advanced cases do tend to improve and the attendant disa-

bilities to become lessened when removed from asbestos dust.

7. Asbestosis does not predispose to tuberculosis.

8. From my observations asbestosis is not primarily a progressive disease.

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RADIOGRAPHIC FINDINGS IN PULMONARY ASBESTOSIS

1. Emphysematous Type of Chest.
2. Flaring of Lower Ribs.
3. Trachea not Displaced.
4. Diffuse Fine to Coarse Fibrosis Reaching the Periphery, Interstitial in Character, Differentiating it from the Roentgenologic Appearance of Silicosis.
5. Hazy Ground-glass Appearance of Lung-fields.
6. Increased Density of All Pleural Markings.
7. Shaggy Appearance of the Cardiac Outline.
8. Tendency Toward Right-sided Cardiac Enlargement.
9. Disproportionate Rise of Left Diaphragm.
10. Degree of Cardiac Involvement is not Consistent with that of Pulmonary Involvement.

THE INFLUENCE OF WAVE LENGTH ON DEPTH DOSE AS MEASURED BY PHYSICAL AND BIOLOGICAL MEANS[1]

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From the Biophysical Laboratory, Memorial Hospital, New York City

THE problem before us is to bring forth the evidence dealing with the question of the relative biological effectiveness of different wave length radiations.

For a good many years, radiations varying in wave length from a few Ångstroms (x-rays) to a few hundredths of an Ångstrom (gamma rays) have been employed in cancer therapy, yet no clear-cut impressions have been reached as to the relative efficiency of these radiations in bringing about favorable clinical reactions. It might be concluded from this fact that no significant wave length effect could exist or it would have been discovered long before this. However, because gamma-ray intensities are generally lower than x-ray intensities and because the methods of administering the two radiations are quite different, the comparisons have not been on the same basis and accordingly the results have not been strongly significant. Moreover, in clinical observation, it is difficult to obtain a satisfactory quantitative measure of the various biological changes induced, thus making exact comparisons impracticable.

With the advent of "supervoltage" x-rays and the prospects of having artificially produced gamma rays in large quantities obtainable under conditions comparable to x-rays, it is desirable to know whether any real advantage, aside from increased depth dose, is to be obtained by using the shorter wave length radiations in the production of radiobiological changes.

In view of the fact that conclusions on this question have not been reached in the clinic, and that, on the basis of this, the very existence of a wave length effect has been questioned, it is natural that experiments should have been undertaken in the laboratory and that the most favorable test materials should have been employed for the investigation of the wave length problem. Should it be demonstrated definitely in any set of organisms that quality of radiation (wave length) as well as quantity (dose) is important in producing irradiation changes, it will then be time to investigate precisely the clinical implications, and the necessary effort involved will be justified.

We have compared the action of different wave length radiations on *Drosophila* eggs and a certain type of ionization chamber, and found that these objects respond in essentially the same way to the different radiations. That is, when we find by ionization measurements (using a certain ionization chamber) that the intensities of the two qualities of radiation are the same, equal exposures produce approximately equal killing effects on the eggs. On the basis of this alone we would conclude, as Packard has concluded (1), that quality of radiation is unimportant and only quantity, or dose, is to be taken into account when producing biological changes with radiation. Experiments have been carried out with other test objects, however, and these have caused us to reserve decision on the question. Furthermore, it seems risky to base conclusions on ionization measurements (in roentgens) of different qualities of radiation, for it has been shown by a number of investigators (2, 4, 6, 8) that such measurements are dependable only within certain wave length ranges (lower voltage x-rays).

In 1931, we (Failla and Henshaw) irradiated *Drosophila* eggs and the seedlings of *Triticum* (wheat), using 200 kv. x-rays in one case and gamma rays in another and found approximately the same relative effects produced by the two radiations. Despite the fact that animal material was used in one case while plant material was

[1] Presented before the Radiological Society of North America, at the Twenty-first Annual Meeting, at Detroit, Dec. 2–6, 1935.

used in the other, and the fact that the amount of killing was the effect measured in one organism while retardation in growth was the effect measured in the other, the same results, in general, were observed. Accordingly, since we found no significant difference and since negative results in this case are trustworthy, our attention was turned from the direct study of the effectiveness of different wave length radiations to a different method of investigating the problem.

It is well known that a beam of x-rays becomes softer, that is, increases in wave length, as it passes through a scattering and absorbing medium. Thus, by placing organisms at different levels in a medium, such as paraffin, they are subjected to different wave length radiations. By comparing, then, the effects observed at the various depths, some impression may be gained of the significance of wave length within the range generated by the scattering medium. Following such a procedure, we undertook to determine whether the same relative depth dose was observed with different test materials at different levels in a paraffin phantom when different wave length radiations were used as the incident beam. Stated more specifically, we attempted to determine whether depth dose curves for 200 kv. x-rays and gamma rays are the same according to observations made on different biological objects. Preliminary results presented previously for both 165 kv. x-rays and 650 kv. x-rays indicate that depth dose curves are not the same for different test objects. The present work is an expansion of this investigation to include a greater range of wave lengths and certain other test objects.

While determinations have been made with a number of test objects, experiments will be described for only one ionization chamber (Chamber A) and two types of biological material—seedlings of *Lactuca sativa L.* (lettuce) and *Triticum aestivum L.* (wheat). Results obtained with *Lactuca* and *Triticum* were selected because they show more interesting responses to the different radiations and because our investigations have been carried further with them. Since extensive experiments have been carried out by Failla and his collaborators (3) to determine the influence of wave length on ionization measurements made at different depths in a scattering medium with ionization chambers, it was necessary for us to use only one of these chambers to relate our findings with biological materials to theirs obtained by physical means.

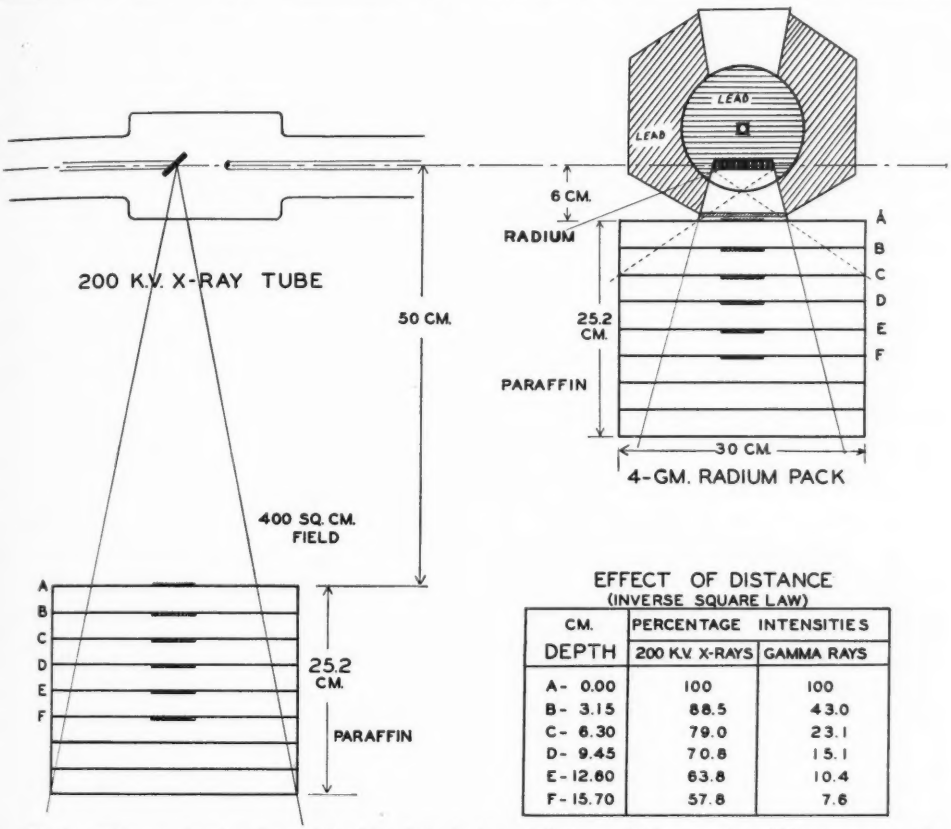
RADIATION AND APPARATUS

The gamma rays employed were obtained from a 4-gram radium element pack used generally for clinical work in this institution. A detailed description of this has been given elsewhere (1). At present, it is necessary to mention only that the radium element is contained in a series of platinum capsules which are distributed over an area 7.5 cm. in diameter in the interior of a heavy lead housing, and that the nearest the phantom could be placed to the radium was 6 cm. (Fig. 1). In addition to the filter provided by the platinum capsules, a piece of bakelite 3 mm. thick was placed just above the test material to stop secondary radiation.

The x-rays were obtained from an ordinary heavy glass, tungsten target, water-cooled, 200 kv. Coolidge type x-ray tube. The conditions maintained during treatment are given below.

The phantom employed was made of paraffin since this substance has an atomic weight about the same as that of tissues and, therefore, has somewhat analogous scattering and absorbing properties. Large discs 30 cm. in diameter and 3.15 cm. thick were moulded. Eight of these were arranged one above the other making the phantom 25.2 cm. deep. Small cavities were excavated into the surface of certain layers to accommodate the test materials irradiated. The cavities for *Lactuca* were 2 mm. deep while those for *Triticum* were 4 millimeters. Thus, since there was no cavity at the surface, and since distances were measured from the middle of the organisms at the surface to the middle of the

organisms at the different layers, the depth distances differed slightly for the different materials used. These differences are taken into account in the graphs presented. Since the cavities differed somewhat for each material used, further mention will be made of them later.



EFFECT OF DISTANCE
(INVERSE SQUARE LAW)

CM. DEPTH	PERCENTAGE INTENSITIES	
	200 K.V. X-RAYS	GAMMA RAYS
A- 0.00	100	100
B- 3.15	88.5	43.0
C- 6.30	79.0	23.1
D- 9.45	70.8	15.1
E-12.60	63.8	10.4
F-15.70	57.8	7.6

Fig. 1. Diagram showing the relationship of the factors of distance, field, etc., when 200 kv. x-rays and gamma rays from a 4-gram radium element pack are used.

PROCEDURE

In carrying out the experiments, a number of things had to be taken into consideration. First of all, in order to eliminate time factor effects during treatment, it was necessary to adjust the intensity of the two radiations to be approximately the same. Since the gamma-ray intensity from the 4-gram pack remained fixed, it was necessary to adjust that of the x-ray beam accordingly. This necessitated some means of measuring the two types of radiation in a common unit. In the absence of a better means, the small ionization chamber (Chamber A), mentioned above, was used for this. Chamber A was first calibrated in a beam of x-rays to give readings in roentgens; it was then placed under the radium pack at a point where the nearest test materials were to be irradiated (6 cm.) and the intensity determined. The reading obtained was 12.2 "roentgens" per minute. While the term *roentgen* is used here, it is not to be inferred that the gamma-ray intensity was measured in accordance with the definition of the roentgen, even though the chamber was calibrated to give readings in roentgens.[2]

[2] A more complete discussion of this subject will be presented by us in a separate communication to be published in RADIOLOGY.

Having found the intensity of the gamma-ray beam to be 12.2 r/min., the ionization chamber was placed under the x-ray machine at 50 cm. distance from the center of the target, and the conditions adjusted to give 12.2 r/min. Since it was impossible to use a 6 cm. distance, as in the case of the gamma-ray treatments, 50 cm. was chosen because it has been used more or less as a standard distance for x-ray work (Fig. 1). The settings, conditions, etc., were as follows.

200 kv.
169 pv.
30 ma.
32 standard cell
94 galvanometer
3.23 mm. Cu, 2.4 mm. celluloid } filter
34 cm. distance to filter
14 × 14 cm. diaphragm at 35 cm. distance
400 sq. cm. field at 50 cm. distance
(surface of paraffin)

A heavy filter was used in order to cut down the intensity without having to lower the voltages. The standard cell galvanometer arrangement was a device for keeping the intensity constant during treatment. It consisted of an ionization chamber which remained fixed in an otherwise unused portion of the x-ray beam and which was connected to a sensitive galvanometer. By adjusting the primary voltage to keep the galvanometer reading constant it was certain that the x-ray intensity remained practically constant.

Thus, as measured in air with a certain ionization chamber, the intensity of the x-rays and gamma rays were the same at the 50 and 6 cm. distances, respectively. The gamma-ray intensity, of course, was fixed and needed no further attention during the course of the work. Special ionization readings were taken from time to time, however, to check the x-ray intensity and the galvanometer measurement of it, since there was a slight tendency to drift.

Having adjusted the intensities of the two radiations to be the same (by ionization), and having made provision for keeping them constant for a period of time, it was possible to proceed with the depth dose measurements.

Before describing the work, however, mention should be made of two factors which differed appreciably for the x-ray and gamma-ray treatments—distance and size of field. As mentioned above, the gamma-ray intensity at 6 cm., the nearest point at which test material could be placed, was low, making it impracticable to use greater distances. Such a distance, however, obviously could not be used under the x-ray tube. Aside from the shape of diaphragm used, the distance differences alone were sufficient to cause the size of field and irradiated volume in the phantom to differ markedly. Figure 1 has been drawn (to scale) to show these differences more clearly.

TABLE I.—MM. LINEAR GROWTH OF 25 ROOTS

Minutes Exposure	0	45	90	135	180	225
Exp. No.	A Level—(Surface)					
1	892	580	508	451	387	310
2	930	768	619	483	416	357
3	904	633	531	361	312	227
4	979	650	545	403	338	246
5	972	717	508	278	229	210
6	1,087	882	716	534	386	332
7	1,006	649	566	556	431	328
8	845	678	604	481	367	328
9	923	643	506	416	339	235
10	724	443	412	322	279	242
11	933	677	452	264	...	212
12	929	517	425	334	247	188
13	921	540	279	176	146	116
14	953	658	513	238	205	177
15	1,033	634	563	215	172	162
16	849	678	535	318	255	230
17	952	752	427	280	182	179
Average	931	653	513	359	293	240
Percentage	100	70.1	55.1	38.6	31.5	25.8
	D Level—9.65 cm. Depth					
1	892	599	549	525	425	420
2	930	817	790	760	648	538
3	904	800	634	590	513	449
4	979	696	655	599	581	564
5	972	825	750	736	554	543
6	1,087	1,010	867	764	673	640
7	1,006	806	695	614	599	546
8	845	732	676	627	621	576
9	923	717	656	526	520	499
10	724	504	448	374	368	366
11	933	781	688	668	572	500
12	929	568	565	559	509	425
13	921	657	648	539	407	322
14	953	734	722	717	643	479
15	1,033	856	804	719	554	521
16	849	774	746	718	577	502
17	952	864	828	663	449	434
Average	931	750	690	629	542	490
Percentage	100	80.6	74.1	67.6	58.2	52.6

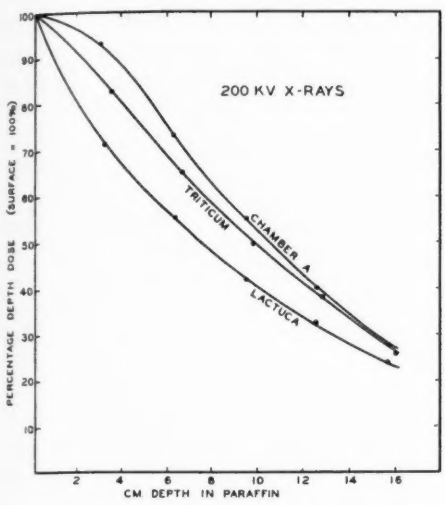


Fig. 2.

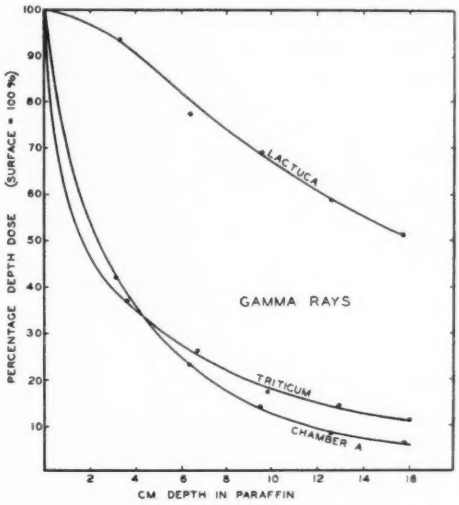


Fig. 3.

Fig. 2. Depth dose curves for Chamber A, *Triticum* and *Lactuca*, obtained with 200 kv. x-rays.
Fig. 3. Depth dose curves for Chamber A, *Triticum* and *Lactuca*, obtained with gamma rays.

While we should have preferred to have these factors the same for reasons of simplicity, they do not interfere with the determination of relative wave length effects on different materials. As will be seen, the shape and location of the depth dose curves will differ in the two cases, but what we are concerned to learn is whether the curves obtained with different test objects are the same for a given radiation. To determine this it is not necessary to have the distance and irradiated volume of medium the same in each case. It will be seen, nevertheless, that while the irradiated area at the surface in case of the radium pack is smaller than in case of the x-ray set-up, the irradiated volumes are not greatly different, so that the absorbing and scattering properties of the phantoms in each case are reasonably alike.

IONIZATION MEASUREMENT OF DEPTH INTENSITY

Ionization measurements carried out at various depths of the paraffin phantom were made with Chamber A, which was spherical and made of celluloid 1.4 mm. thick and having an inside diameter of 1.52 centimeters. For the surface measurement, the chamber was arranged half submerged in the surface of the first layer of paraffin, while for the others it was placed between the layers at the various depths. In all cases, the paraffin was moulded around the surface of the chamber to avoid air spaces. When measurements were made under the radium pack, the surface of the phantom was placed at 6 cm. distance from the radium and always in such a way that the ionization chamber was at the center of the beam. When x-ray measurements were made, the phantom was similarly arranged except that the surface was at 50 cm. distance (Fig. 1). Since the findings here have a bearing on several other investigations, they were carried out with all possible precision. The results obtained are shown in Figures 2 and 3.

BIOLOGICAL MEASUREMENTS OF DEPTH DOSE

Complete depth dose curves have been obtained with the seedlings of *Lactuca* and *Triticum* for both x-rays and gamma rays. In both organisms the effect observed was retardation in linear growth of the primary root. The procedure followed, and the

TABLE II.—EXPOSURE VALUES AND RATIOS FOR CORRESPONDING EFFECTS PRODUCED AT DIFFERENT LEVELS IN THE PARAFFIN PHANTOM

Level	A	B	C	D	E	F
	Minutes Exposure					
% growth						
77.5	25	34	46	65	90	123
75.0	32	44	58	79	108	144
72.5	39	54	70	96	126	165
70.0	46	64	84	109	144	187
67.5	53	76	97	125	162	208
65.0	61	86	110	141	180	228
62.5	68	98	123	156	198	
60.0	76	108	137	172	216	
	Percentage Effect at Surface					
77.5	100	73.5	54.3	38.4	27.8	20.4
75.0	100	72.7	55.1	40.5	29.6	22.2
72.5	100	72.1	55.8	40.6	31.0	23.6
70.0	100	71.8	54.7	42.2	32.9	24.6
67.5	100	69.7	54.6	42.4	32.7	25.5
65.0	100	71.0	55.5	43.2	33.8	26.8
62.5	100	69.5	55.3	43.6	34.4	
60.0	100	70.4	55.5	43.9	35.2	
Av.	100	71.3	55.1	41.9	32.2	23.9

variation in results obtained in each case were about the same so that details will be given for only one—*Lactuca*.

Germination in this organism was induced by wetting the seeds and maintaining them in a moist chamber on moist filter paper at 26° C. ± 2.0. After 18 hours the primary root is just beginning to break through the seed coat; this is the stage at which treatment was administered. For treatment, the seedlings were arranged evenly on moist sectors of a circle of filter paper. Six such circles (five sectors each) were prepared and arranged as follows: Cavities 5 cm. in diameter and 2 mm. deep were made in the surface of the second, third, fourth, fifth, and sixth paraffin layers at the center. Filter paper circles containing seedlings were placed in each of the cavities and one was placed on top of the first layer. Treatment was then begun and one sample (sector of seedlings) was removed from each level at the end of each of the following exposures—45, 90, 135, 180, and 225 minutes. Experiments with x-rays and gamma rays were not performed simultaneously nor were they done on alternate days, but a few of one and then a few of the other were done, depending on when the radium pack was available. Each sample of material was placed in a separate moist chamber and the seedlings spread evenly over the available area. At the end of treatment, all samples, together with controls, were put away in an incubator at 26° to await growth.

At the end of 96 hours after treatment, the linear growth of 25 primary roots was measured for each sample treated. A sample of data obtained is shown in Table I which gives the results for tests made at the surface and at the D level (9.65 cm. as used for *Lactuca*) with x-rays.

Values were averaged in each case and expressed in percentage growth of the controls. The percentage values were then plotted as shown in Figure 4, presenting a family of dose-effect curves for the different levels in the phantom. Table II shows the minutes of exposure (taken from Figure 2) required at each level in the phantom to retard the growth to certain corresponding amounts. In the lower part of this table, these values are expressed in percentage with the effect at the surface taken as 100 per cent. The averaged values, together with similar ones obtained with *Triticum* seedlings, are shown for x-rays in Figure 2. Likewise, in Figure 3 the depth dose curves for *Lactuca* and *Triticum* are shown for gamma rays.

DISCUSSION OF RESULTS

It is evident from Figures 2 and 3 that the curves for different test objects present significant differences.

Referring first to the 200 kv. x-ray results, it is seen that while the curves follow the same general course there is some separation between them. The curve for Chamber A is above those for *Triticum* and *Lactuca*, and the curve for *Triticum* is above that for *Lactuca*. This indicates that the ionization chamber detects relatively more radiation at the depths than do the biological test objects, and that *Triticum* detects more than *Lactuca*. While the differences

are not large, they are, nevertheless, appreciable. Furthermore, it is interesting to note that although the conditions (distance filter, field, and intensity) are somewhat different, the curves for Chamber A and *Triticum* bear the same general relation to each other as those described previously for 165 and 650 kv. x-rays, thus bearing out the conclusion that biological and ionization measurements of radiation intensity are not necessarily the same.

Examining now the gamma-ray curves, marked differences are observed. Not only is the order of their position changed but also there is wide separation and crossing. Whereas the *Lactuca* curve fell beneath those for Chamber A and *Triticum* when 200 kv. x-rays were used, it lies well above them when gamma rays are used. The curve for Chamber A follows a smooth course and is not greatly different from that based on the Inverse Square Law (see the Table, Fig. 1). The *Triticum* curve drops away more rapidly at first, then crosses the ionization curve at 4 to 5 cm. depth, and rises above it. From the experimental points plotted in Figure 3, some question might arise as to whether the crossing of the *Triticum* and Chamber A curves is exaggerated. To investigate this, points were obtained for shallower depths and the curves verified. These additional points have not been included because the exposure conditions differed slightly.

It appears, therefore, that as far as *Triticum* is concerned, the effective radiation drops off rapidly near the surface in the phantom, and then, due to some *compensatory* action, remains almost constant. The term "*compensatory*" is used because, by the Inverse Square Law alone, the intensity would drop away more rapidly than indicated by the *Triticum* curve.

Comparison of the curves of *Triticum* and Chamber A (gamma-ray data) indicates evidence of differential effects at different levels in a paraffin phantom; comparison of the *Lactuca* curve with those of *Triticum* and Chamber A demonstrates even greater differential effects. At 10 cm. depth, for example, the radiation intensity

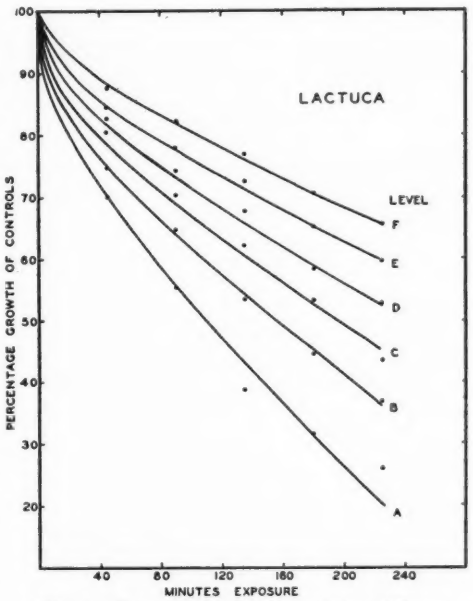


Fig. 4. Dose-effect curves obtained at different levels in a paraffin phantom.

as detected by *Lactuca* is several times that detected by *Triticum* and Chamber A, and correspondingly wide differences exist throughout the extent of the curves.

Hence, since the flux of radiation present at any level must be the same, irrespective of the test object used, the differences observed would seem to be due to the differential effectiveness of the different qualities of radiation present at the various levels. The magnitude of differential effect manifest, however, is so great and unexpected, in view of the fact that direct comparison of wide wave length differences revealed no significant differences, that we were led at once to question the experimental results. Accordingly, calculations have been checked carefully and a variety of experiments have been carried out to locate possible errors. Some variation was obtained when the experiments were performed in different ways, but none which compares to the magnitude of difference separating the *Lactuca* curve from the other two when gamma rays are used. However, since circumstances may yet arise which would make it necessary to interpret the results in another way, we wish

merely to present the findings here as an experimental observation suggesting a differential effect due to wave length.

SUMMARY

Intensity measurements of x-rays and gamma rays have been made at various levels in a paraffin phantom using an ionization chamber and two types of biological test objects. Curves showing how intensity varies with depth in each case were found to be generally alike for x-rays and quite different in the case of gamma rays.

Such results indicate a differential response on the part of the test objects, and since, so far as we know, radiation at different levels in a scattering medium differs only with respect to wave length, these results suggest a differential effect produced by different wave length radiations.

The writers wish to express their indebtedness to Dr. G. Failla for helping to plan these investigations and for his interest and co-operation throughout the course of the work. Thanks are also due to members of the Physics Department for making the ionization measurements.

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ACUTE GASTRIC DILATATION OF STOMACH DURING ATTACK OF MIGRAINE

By J. KAUFMAN, M.D., *and* I. LEVINE, M.D., *Brooklyn, N. Y.*

MIGRAINE has been defined as an affection characterized by paroxysmal attacks in which a distinctive type of headache, usually unilateral, is the most constant feature, commonly accompanied by nausea and vomiting. This condition is more common in females and occurs preponderatingly in neurotic families. The immediate exciting cause of an attack in individuals who are predisposed to it is any undue fatigue or excitement of the nervous system.

These patients very often show symptoms suggestive either of an irritation or paralysis of various components of the sympathetic system. The close relationship of the stomach to the autonomic nervous system accounts for the marked frequency of gastric symptoms in cases of migraine.

The etiology is considered by some authorities to be due to local angio-spasms causing focal symptoms in the brain; by others, to be due to recurring auto-intoxication, refraction anomalies, nasal disease, etc. Goldzieher (2), in discussing headache of the migraine type, states that it may be on a definite endocrine basis, and that recent investigations have added new indirect evidence that headaches of the migraine type are related to increased intracranial pressure. Such patients show the appearance of the anterior pituitary hormone in the urine prior to the onset of the headache. Hyperfunction of the anterior lobe and spilling of the hormone in the urine are constant features of increased intracranial pressure, which is probably due to water accumulation in the brain tissue.

Fig. 1.

Fig. 2.

Fig. 1. Showing the marked gastric dilatation and atony during the attack of migraine.
Fig. 2. Showing the same stomach completely recovered after the attack had subsided.

Hunt (1) investigated 60 cases of migraine, 40 of which had symptoms referable to the gall bladder. In 17 cases, oral cholecystography showed evidence of gall-bladder or hepatic disorders. He found that gall-bladder disorders were more frequently encountered in patients with mi-

graine than in normal patients, and consequently stressed the importance of inquiring about migraine in patients with gall-bladder disease.

Vaughan (4) reported 33 cases of migraine, 36 per cent of which were due to allergenic foods. More than one-half of these patients complained of vomiting. Mackintosh and Anderson (5), in discussing migraine, state that nausea and loss of appetite occur in the large majority of cases and that as a rule any food taken is not digested, all digestive and absorptive processes in the alimentary canal appearing to be in abeyance in severe attacks.

We present the following case because of the graphic manner in which it demonstrates the marked changes that the stomach can undergo through nervous stimuli, and because it stresses the importance of a thorough clinical history before any conclusion can be drawn from the x-ray examination.

F. H., female, aged 35 years, married, was referred for radiographic examination because of repeated attacks of migraine associated with nausea and vomiting. The family history is important, in that the patient has a sister who suffers from ærophagia. The patient's history is irrelevant, other than the fact that she has always been a "nervous" individual. The present complaint dates back three years, at which time she began to complain of left-sided headaches, which increased in severity and were associated with nausea and vomiting. Correction of a refractive error did not improve the condition.

Radiographic examination of the fasting stomach (patient had no food or drink for 15 hours prior to the examination) revealed a tremendously dilated stomach. Under fluoroscopic examination it was obvious that, in spite of the abstinence from food, there was considerable retention of both fluid and food in the stomach. The stomach was atonic. The barium filtered through the gastric contents and settled to the bottom of the stomach. Throughout the fluoroscopic and plate examinations no evidence of peristalsis was noted. Very little barium passed through the duodenum. The patient vomited twice before the six-hour plate was taken, but nevertheless there was a retention of about 60 per cent of the meal on the six-hour plate. At the time of this examination the patient was having an attack of migraine, and another examination was advised when the attack subsided. The second radiographic examination, taken 24 hours after the attack had subsided, revealed a fish-hook type of stomach, the lower border being at the level of the iliac crests. Peristalsis was active. No defects of form or function were observed either in the stomach or duodenal bulb. In six hours the meal showed normal motility.

CONCLUSION

A case of migraine is presented, showing acute dilatation of the stomach during an acute attack with recovery subsequent to the subsidence of the symptoms. This type of case is being investigated further to determine the consistency of the radiographic findings, and also in an attempt to judge the efficacy of the various medicaments through their action on the stomach as judged by the radiographic examination.

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SOME LAWSUITS I HAVE MET AND SOME OF THE LESSONS TO BE LEARNED FROM THEM[1]

(Tenth Installment)

By I. S. TROSTLER, M.D., F.A.C.R., F.A.C.P., *Chicago*

A GOITER CASE (*res ipsa loquitur* DOES NOT APPLY IN WISCONSIN[2])

A CASE of roentgen dermatitis referred for opinion and advice, which was rather roughly handled by the writer (the case, not the patient), ended far differently from the way we anticipated and foretold.

An attorney for an insurance company wrote as follows: "A case prosecuted by a Mrs. D. K., of F——, Wis., against Dr. G. T. B., of the same city, is pending in the Circuit Court and will be tried within a short time in that city. The plaintiff is represented by Messrs. R—— and O'B—— and the defendant by Mr. J. F. K——, of the law firm of B. H. K. & D., of Oshkosh, in our behalf.

"From a report submitted to us by Dr. B——, he advises us that he was treating Mrs. K——, a widow, approximately forty years of age, for goiter. He was using a Victor Universal machine and says that his first treatment was administered April 21st last. His factors were 5-inch spark gap, 6 ma. of current, for 6 minutes through 2 mm. aluminum, at 13 inches anode-skin distance. The treatment was renewed on April 29th, May 5th, and May 12th. It appears that during June and July, the Doctor was on his vacation in Europe and on his return on July 21st and a week later, to-wit, July 28th, two more treatments were given the patient, the factors being the same with the exception of filtration, which was reduced to 1 mm. of aluminum. On or about the 6th or 8th of August, evidences of a burn became apparent.

"Commencing May 2nd and continuing on the 7th and 14th of May, July 24th, 29th, and 30th, the Doctor gave what he called a tonic treatment, quartz light or ultra-violet ray. The time for this varied from one to six minutes. This was not given at that time as treatment for any burn, because no burn had at that time asserted itself.

"The ultra-violet ray treatment was continued on the following dates: August 1st, 3rd, 8th, 10th, 12th, 14th, 17th, 19th, 22nd, 24th, 26th, 28th; September 1st, 3rd, 5th, 7th, 9th, 11th, 14th, 16th, 18th, 21st, 23rd, 25th, and 28th, and the time of each treatment varied from one to six minutes, according to the judgment of the Doctor, based on the condition of the patient and the burn from time to time. The idea of the ultra-violet ray treatment was to cure the burn.

"Assuming, a spark gap of 5 inches, milliamperage of 5, and a 13-inch distance which the Doctor reports, through 1 mm. of aluminium, we figure, according to the Witherbee and Remer formulæ, that 4 minutes and 22 seconds would be a skin unit, or 31 minutes and 2 seconds an erythema. So far as the factors are concerned, a burn should not have occurred.

"It seems that the filtration was shortened at the suggestion of some London Doctor whom Dr. B—— met, while sojourning in Europe. As soon as the filtration was reduced to 1 mm. of aluminum, the burn came into evidence.

"It is our understanding that the point of the burn is under the right ear. We understand the anode arm of the tube was directly above the right ear.

"We attempted to account for the burning in the following manner, which we sug-

[1] The Editor desires to state that much of the matter herein has to be printed in form as received, without normal punctuation or phrasing.

[2] Kuehneman *vs.* Boyd, 214 N.W.R., 326 (1927).

gested to Mr. K——, and he desires confirmation of our theory. We copy from our letter to Mr. K——: 'We understand the severest burn is about the ear. We offer the following reasons for that burn: Assuming the positive pole of the x-ray tube to be immediately above the right shoulder of the patient, we take it that x-rays are discharged through the arm of the positive pole. The discharge of x-rays through the positive pole end of the tube cannot and was not, at the time the services were rendered plaintiff, controllable. That x-rays were discharged through the positive arm of the tube was evidenced by the fact that much x-ray equipment and especially the tubes are now being furnished with the tube fully enclosed in a lead cylinder. For your information, a photograph of such enclosure torn from the "American Journal of Roentgenology" is herewith enclosed and your attention is called to the enclosure for the tube.

" 'We are also enclosing herewith a sketch of a Coolidge tube which we have marked with the negative and positive poles. The positive pole supports what we have marked as *D*, which is the anode or target, and the arm, of course, would be called the target arm anode arm. The potential on the negative pole is controlled through the autotransformer. A suitable potential is first applied to the cathode which has the effect of releasing the electrons. In order to actuate this tube, it is necessary to have a suitable high potential current. In the Coolidge tube the electrons are liberated from the atoms of the tungsten filament by means of heat. In the Coolidge tube they arise at the filament which we have marked as *C*, which is more or less encased in a focussing cylinder, which we have marked as *B*. When the electrons are available, a suitable potential is applied to the tube terminal, and causes the electrons to leave the cathode and travel to the anode at a high velocity. This stream of electrons is known as the cathode ray. At the target, upon which the cathode stream is focussed by virtue of the concave cathode which we have marked *A*, the electrons are suddenly arrested, giving rise to electro-magnetic pulses which travel in all directions from the target. These electro-magnetic pulsations or waves are the x-rays.

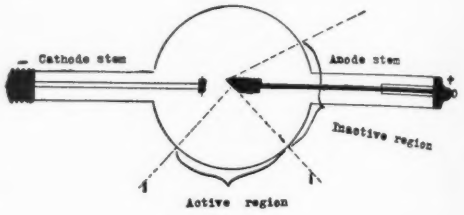

Fig. 1.

" 'Attention is called to the fact that the electro-magnetic pulses, which are other words for x-rays, travel in all directions from the target. Immediately beneath the cathode and anode of the tube is a space called the active hemisphere and beneath this and to the equipment is attached a cone for the purpose of directing the rays to the spot to be irradiated. These cones are usually made of lead and, of course, lead is impervious to the x-ray. The rays will not pass through the cone, that is, the sides. However, between the points that we have drawn in red on enclosed diagram, there are x-rays and, since they cannot be controlled, there is a probability that these rays passing down on to a part of the body not under irradiation and cause a burn.

" 'It is well to keep in mind that it is the long wave x-ray that does the harm. The long wave length is due to a small voltage. In this particular case they were using about 5-inch gap, or approximately 50,000 volts, which is very small in x-ray therapy.

" 'If some doctor, acquainted with radiology, would testify that it is possible to have a discharge of the x-ray back of the target or through the positive pole or arm of the tube, and that there is no way or at least there was no way of controlling these rays at the time the services were rendered plaintiff, we do not believe that liability should be imposed upon us, as a result of the passage of the rays through that arm of the tube. Undoubtedly this could happen, otherwise there was no necessity for en-

casing the full tube in a cylinder as was evidently done by the Peerless Electro-medical Corporation, as evidenced by their advertisement which is enclosed herewith.'

"For your information, we are enclosing a rough sketch (Fig. 1) of an x-ray tube. We have outlined what we term the anode region, contending that within the red lines there is always a constant x-ray discharge. We understand this is correct. Assuming x-ray discharge through the anode arm of the tube, what could a roentgenologist do to avoid burning a patient on any region of the body that may be exposed to the rays beneath the anode arm? We assume this will be readily answered by saying that lead foil should be used.

"Mr. K——, in a letter to us, makes the following inquiries: 'I have an appointment with Dr. B—— for this afternoon. I have asked him to come to Oshkosh. I want to present to him and Mr. C——, of the Oshkosh Clinic, the theory advanced by you. If this theory can be supported and we can locate the initial point of burning as back of the ear or some distance removed from the point irradiated, the defense suggested seems to be complete. Could we not get some help from the manufacturer? When did the improved tube first make its appearance? When were the escaping x-rays through the arm first discovered, or, more to the point, when was the preventative first put into use? By whom could that be established?'

"We are taking the liberty of submitting this case to you and would be very pleased to have your suggestions.

"We are especially interested in knowing whether or not you are licensed to practise medicine in the State of Wisconsin. A license is now necessary in order to qualify as an expert witness in that State, as the statutes now provide that all experts shall be licensed to practise within the borders of that State.

"In the event that you agree with our theory and are licensed to practise in Wisconsin, we would be very pleased if you would advise us of that fact so that we may communicate with Dr. B—— and Mr. K—— to arrange to see you and arrange for your presence at the trial."

The familiarity of the attorney who wrote the foregoing letter, with roentgen phraseology, the Coolidge tube, etc., is one of the principal reasons why the writer has for years advocated that we carry our malpractice insurance with companies that know how to fight. How many attorneys in this country could write such a letter? I venture to say that not ten could do so.

I replied as follows: "*In re* K—— *vs.* B——, relative to the above captioned case, will say that, while the technic described (5 in. spark gap, 5 ma., 6 min., 2 mm. Al filter at 13 inches F.D.) might not produce a burn under ordinary conditions, when this same dosage would be applied to a patient having a goiter, four successive times at 7-day intervals, in my opinion it would be considered by almost any experienced roentgenologist as overdosage and not proper treatment for goiter. When the same technic (except one millimeter of aluminum was used instead of two, for filter) for two later applications at weekly intervals, it is my opinion that whoever did so apply the second series displayed further ignorance of what is proper treatment and great lack of knowledge of approved methods in the treatment of the disease under discussion. It is generally known that goiter patients do not tolerate full dosage of x-rays.

"The administration of the ultra-violet radiation along with, and at the same time as, the x-rays is in agreement with the methods of but one writer and he is discredited. It is a method advocated by the representatives of the manufacturers of lamps and apparatus which generate those ultra-violet rays and is by these commercially tainted men claimed to produce a greater tolerance to large doses of x-rays. Careful investigation and proven experimentation by some of the best and most careful and competent radiologists in this country have proven that this claim and these claims are absolutely without foundation in fact. Recent publications have reproven this.

"I fail to understand your methods of computation, when you say in the first new paragraph on page 2 of your letter, 'assuming a spark gap of 5 inches, ma. of 5 and a 13-inch distance, which the Doctor reports,' etc., to the end of the paragraph. According to Shearer's formula on page 137 of MacKee (2nd Ed.), the equation according to the figures you give would be

$$\frac{5\,(\text{ma.}) \times 5\,(\text{S.G.}) \times 6\,(\text{min.})}{13 \times 13\,(\text{F.S.D.})} \text{ equals } \frac{150}{169} \text{ or practically } \frac{15}{17}.$$

"The above figures would be for unfiltered radiation, of course. With one millimeter of aluminium filter, nearly twice the above might be administered with reasonable safety *once in three weeks*. With two millimeters of aluminium as filter the safety factor would be somewhat greater but not yet absolutely so for *one application in three weeks in a goiter case*. Your client applied the above *four times at weekly intervals* and if this is not overdosage, what is it? And he then applied greater dosage after an interval of ten weeks, but for only two applications seven days apart.

"In regard to the location of the burn being under the anode stem of the tube, will say that this is possible *if the patient was not protected* from such radiation, as it is well and generally known that x-rays are emitted from the back of the entire anode as well as from all along the anode stem of the Coolidge tube. This was described in detail by Coolidge and Moore in April, 1916, in 'The General Electric Review,' under the title of 'Roentgen Rays from Sources Other than the Focal Spot in Tubes of Pure Electron Discharge Type,' and the same paper was presented at the meeting of the two national x-ray societies and published in two magazines of international circulation among x-ray workers. For this reason your defendant should have known about the existence of this condition. In this regard, the sketch of the Coolidge tube (Fig. 1) you sent me is incorrect in that it shows the area 'behind the face of the anode' as the 'inactive region,' whereas it is well known that this region is active and that *it does* emit x-rays. I am enclosing herewith a very crude sketch (Fig. 2) which shows more correctly the distribution of the x-rays.

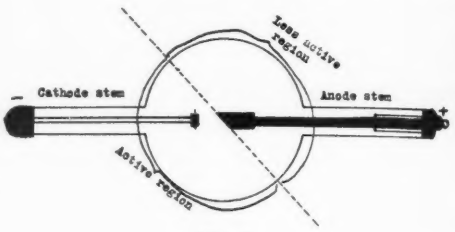

Fig. 2.

"Your assumption that the burn resulted from the rays emitted from the back of the anode and the anode stem may be true; but this is rather unlikely. In other words your theory is correct but this would probably not work out practically because not enough x-rays to produce a burn (with the technic used) should be produced to do much damage; and admitting the possibility that the damage was done by these rays from back of the anode face, *your client should have protected against such a contingency*.

"You say on page 3 in third paragraph, 'it is well to keep in mind that it is the long wave x-ray that does harm. The long wave length is due to a low voltage. In this particular case we were using about 5-in. gap, or approximately 50,000 volts, which is very small in x-ray therapy.' According to Kaye, and verified by myself many times, a five-inch gap (using the usual blunt points fitted to modern apparatus) is equal to about 86,000 volts peak. According to others, it is equal to about 64,000 effective voltage. Modern radiologists compute voltage at peak volt value. And again, more x-ray burns are caused by high voltage and short wave length than by medium and low voltage and medium and long wave length x-rays. I not infrequently use a current of 45,000 in therapy. This gives about two and one-half inch spark gap, and is very efficient in certain skin conditions.

"Replying to the question in Mr. K——'s letter: 'Could we not get some help from the manufacturer?' I take it that he means the manufacturer of the x-ray tubes, and in reply to that will say that it was the employees of the General Electric Co. (Dr. Coolidge and Dr. Moore) who called our attention to the fact that x-rays are emitted from other sources than the focal spot of pure electron discharge tubes as previously stated.

"To sum matters up as I see them from the information received from your letter, will say it is my opinion that:

1. The dosage applied was excessive.
2. Whoever it was who applied or prescribed such dosage displayed a lack of knowledge of the proper treatment of goiter, as well as carelessness in failing to protect against the effect of the x-rays which were emitted from the back of the anode and the anode stem.
3. (*a*) Your theory of how the burn was produced is untenable.

(*b*) If the theory was tenable, your client should have known that he must protect against its effect.

4. Probably no competent expert witness will hold with your claims.

"As regards to my offering suggestions, will say that as I see it, you 'have no leg to stand on,' so that, as much as I dislike even the consideration of a settlement, it seems to me that settlement is the only sensible thing to do in this case."

This case came to trial in due time and, as might be expected, resulted in a verdict in favor of the plaintiff with judgment for $5,000 damages and costs. I did not attend the trial. The case was then taken to the state supreme court on an appeal.

While it is clearly evident to anyone at all familiar with the subject that the defendant was guilty, and the jury found him so, the supreme court (with one judge absent and another dissenting) decided to reverse the judgment and remand the case with instructions to dismiss plaintiff's complaint. However, the case was reviewed by this court, and later remanded to the lower court for retrial as related later.

Because of the importance of this decision it is quoted almost verbatim.[3]

"The defendant is a physician and surgeon in the practice of his profession in the city of F——. Early in the Spring of 1925 he undertook the treatment of a toxic goiter from which the plaintiff was suffering. He gave her alternate treatments of the x-ray and the actinic ray. He gave a treatment of each ray once a week for a period of five weeks, when he went to Europe and was absent for about ten weeks. During the period of treatment her condition improved steadily and satisfactorily, and no untoward results of the application of the treatments were observed. No burn resulted and there was nothing to indicate that her skin was hypersensitive to the rays. While in London attending a meeting of a medical society, the defendant was told by a doctor that if he would remove one filter from the x-ray machine he would secure quicker results. Upon his return from Europe, he renewed the treatments in exactly the same manner that he had administered them before his departure for Europe, except that in administering the x-ray he used but one filter in the machine instead of two. His first treatment after returning from Europe was administered on July 21st, in the evening. During that night the patient noticed a soreness and burning at the side of her neck along where the treatment had been administered, and in the morning it was still swollen. During that day the swelling went down, and it seemed to feel better, and she paid no further attention to it. This treatment was given on Tuesday. On Friday night she called on the defendant, told him of the soreness of her neck, that it had swollen and 'kind of burned,' but that the swelling had gone down. She said she thought perhaps she had taken a cold. On

[3] It is extremely important to note that the published report of this decision in the N. W. R. is as here quoted. The fact that this case was re-argued before the same supreme court and that a second decision was that the case be remanded for retrial, and that it was settled before the second trial is not on record. As far as the writer knows, this is the first publication of these later facts.

that night he gave her an application of the actinic ray. She noticed no ill effect from that treatment. The following Tuesday, the 28th, she returned to him for an x-ray treatment. At that time nothing was said about the soreness of her neck. During the treatment on the 28th she noticed a sort of prickling sensation, but 'it wasn't bad'; that was all she noticed while she was in the office, but during the night she woke up and there was 'a terrible soreness and burning' on her neck. The next morning she went to his office and asked him what had happened to her neck. He told her that she had an x-ray burn, which he treated with the actinic ray. He continued to treat the burn with the actinic ray until October 5th, after which she consulted another physician.

"It appears uncontradicted by the expert testimony in this case that an x-ray burn is due either to overdosage or to a hypersensitive skin, and that there is no way of diagnosing in advance whether the skin of any individual is hypersensitive to the x-ray. It is fundamental that, in order to recover in this case, the burden is upon the plaintiff to prove negligence on the part of the defendant in administering the x-ray treatments. In order to support the conclusion that the burn was the result of defendant's negligence, it is first claimed that the treatment given prior to the defendant's departure for Europe resulted in no burn, and disproves the fact that the plaintiff had a hypersensitive skin. The defendant admits that in administering the treatment upon his return from Europe he used only one filter in his x-ray machine instead of two, and that this resulted in greater dosage, but this does not prove that the dosage given after his return was an overdosage, or that the dosage given prior to his departure was a normal dosage. It simply proves that the dosage given in the later treatments did burn the skin. It leaves entirely to speculation whether the burn was the result of an overdosage, or whether it was due to the hypersensitiveness of the skin. There is no evidence in the case to establish the fact that the dosage from which the burn resulted was an overdosage.

"It was the defendant's duty to exercise that degree of care, diligence, judgment, and skill which physicians in good standing in the same school of medicine usually exercise in the same or similar localities, under like or similar circumstances, having regard to the advanced state of medical or surgical science at the time he discharged his legal duty to his patient. In order to hold him liable, the burden is upon the plaintiff to show that he failed in the requisite degree of care and skill. That degree of care and skill can only be proven by the testimony of experts. Without such testimony the jury has no standard which enables it to determine whether the defendant failed to exercise the degree of care and skill required of him. [Citing cases.]

"*The doctrine of* res ipsa loquitur *is not applicable to malpractice cases between patient and physician* [author's italics]. The reason for this rule is stated clearly and tersely by Judge Taft, in Ewing *vs.* Goode, 78 Fed. 442, in the following language:

"'A physician is not a warranter of cures. If the maxim, "*res ipsa loquitur*," was applicable to a case like this, and a failure to cure were held to be evidence, however slight, of negligence on the part of the physician or surgeon causing the bad result, few would be courageous enough to practise the healing art, for they would have to assume financial liability for nearly all the "ills that flesh is heir to.'

"There is some disagreement in the authorities as to whether this doctrine applies where results such as arise from x-ray treatments. *We can see no reason why the same rule should not apply to x-ray treatments given by a physician to a patient for curative or healing purposes* [author's italics]. The discoveries of science are continually placing in the hands of physicians new agencies with which to cope with disease. Among such discoveries came the x-ray. It is, undoubtedly, a valuable healing agency, and is coming into quite general use by physicians for treating and curing diseases. Where physicians minister these treat-

ments for curative and healing purposes—where the *bona fide* relation of physician and patient exists—we see no reason why proof of a bad result should constitute proof of negligence on the part of the physician, any more than when any other agency is applied or administered. It is said that the x-ray is a dangerous agency, but, as said by the Pennsylvania court, 'So is a surgeon's knife. If human ills are to be cured, such instrumentalities must be used. To put upon the medical profession, which must use them, such a burden as the financial responsibility for damages, if injury or death results, without proof of specific negligence, would drive from the profession many of the men who should remain in it, because unwilling to assume the financial risks.'

"The great weight of authority holds that the doctrine of *res ipsa loquitur* does not apply under such circumstances. Sweeney *vs.* Erving, 35 App. D.C., 57; 43 L.R.A. (N.S.), 734; Antowill *vs.* Friedman, 197 App. Div., 230; 188 N.Y. Sup., 777; Runyan *vs.* Goodrum, 147 Ark., 228; S.W., 397; Nixon *vs.* Pfahler, 279 Pa., 377; 124 Atl., 130.

"In the instant case there is not only no evidence to show that the defendant administered an overdosage of x-ray to the plaintiff, or that the defendant was in any respect negligent in administering the treatment, but the defendant himself testified as follows upon that subject:

" 'Of the standard authorities that medical men using this kind of instrument follow in this locality, Remer and Witherbee is considered one of the best, and Sampson is another. Remer and Witherbee have developed a formula for every size filter for goiter cases. The technic I used conformed in every respect to the formula of Remer and Witherbee, as to spark gap, milliampere, time, and filter. The time, filter, and distance that I used were within the factor of safety of those rules. The next treatment that I gave was given just exactly the same. The technic and formula that I used conformed to medical standards in this locality.'

"There may be some doubt as to whether the contents of medical works can be intruded in evidence in this manner, but the defendant's statement, that 'the technic and formula that I used conformed to medical standards in this locality,' being undisputed, must be accepted as the standard of the care and skill required of him, and there being no evidence to show that he did not meet this degree of care and skill, there is no evidence to support the verdict for plaintiff.

"Some stress is placed upon the testimony of plaintiff that the Doctor told her that the burn was not the result of accident, but that it was due to a lack of knowledge. It is admitted in the case that the Doctor withdrew one filter from the x-ray machine because of the advice received by him from the physician in London. If the withdrawal of this filter was, in fact, bad practice, the mere circumstance that he was advised so to do by the doctor that he met in London would constitute no defense. If, as a matter of fact, it was the proper practice to withdraw the filter, then it matters not what or who induced the Doctor to pursue the practice. His ignorance is immaterial if his practice is right.

"From what has been said, it follows that the court erred in the following instruction to the jury: 'If you believe from the evidence that, when proper care is used in administering the x-ray in the treatment of goiter, a burning of the patient to the extent here shown is not likely to result, under all the circumstances here involved, then the fact that plaintiff was so burned may be considered by you as evidence that the defendant did not use due care and skill and judgment in administering the x-ray to plaintiff: but in determining this fact you must also consider all of the testimony of the defendant as to proper practice, and dosage and what dosage he, in fact, administered, and decide upon all the evidence bearing upon the point.'

"This charge told the jury that the fact that plaintiff was burned may be considered by them as evidence that the defendant did not use due care, skill, and judgment in administering the x-ray to plaintiff.

In view of what has been heretofore said, it is apparent that this statement was erroneous.

"Judgment reversed and cause remanded, with instructions to dismiss plaintiff's complaint."

This case was re-argued before this same supreme court, after which it was remanded to the district court for retrial. It was settled for $2500 before the second trial came up. If the writer is in the least manner competent to give an opinion, the defendant and his insurance carrier got off cheaply.

It will be recognized that the foregoing opinion, by the Supreme Court of Wisconsin, is one of the best and most favorable ones on record, as far as roentgen therapy and roentgen injuries are concerned, ever given in any court anywhere. It must at the same time be clearly evident to anyone at all acquainted with roentgen therapy, that the defendant in the case was guilty of malpractice as we know the subject of roentgen therapy of toxic goiter—or, in fact, almost any except malignant disease—and that the jury was correct in finding him so. In all due deference to the learned judge of that supreme court, we who know more about the subject that he can and does, need only read the third and fourth sentences of the opinion to realize that the judge was reasoning from false premises, and consequently his first conclusions must have been and were wrong. Evidently the erroneous instructions of the trial judge to the jury (see third from last paragraph of supreme court decision) was the deciding point for the supreme court's first decision.

It will be well for all who have to plan a defense against a suit of this character, to remember this case. It is loaded with much that will help defend and defeat charges of malpractice due to roentgen injuries.

ANOTHER GOITER CASE

In 1929 I received the following letter from a medical friend in central Illinois: "Some time ago I treated a patient over the thyroid by means of roentgen ray, using three portals, one on each side and one over the median line just below, bringing the edges of each surface treated in close approximation to the other two. I used the following technic: 0.23 wave length, 241.8 r, over each area at one sitting, obtained by the following factors: ma. 5; kv.p. 120; distance 20 cm.; time $7\frac{1}{2}$ minutes; portals $3\frac{1}{4}$ cm.

"Realizing that a small amount of filter should be used, I would appreciate your opinion of the skin effect and the ultimate outcome of this amount of unfiltered rays.

"Any suggestions or references will be appreciated."

I immediately replied: "From the technic and figures given, it is my opinion that the skin effect would be the production of a rather marked first degree or a mild to moderate second degree roentgen dermatitis, and that the ultimate outcome of that amount of unfiltered radiation on the average skin would be pigmentation, followed, after a more or less extended period, by telangiectasis and skin atrophy, after healing of the primary dermatitis.

"The foregoing opinion is based upon the assumption that the skin of the patient is of average or normal tolerance and that the figures given are absolutely correct. If there is an hypersensitiveness of the skin of the patient, the effect would, of course, be exaggerated, while, on the other hand, if the skin of the patient be more than usually tolerant, there would be only a slight erythema, followed by slight pigmentation, which would disappear after a lapse of a more or less prolonged interval.

"I am wondering somewhat, why you are asking me these questions, and why you used unfiltered radiation in a goiter case. Surely you do not expect to treat patients with goiter, without the interposition of some filter between the tube and the patient's skin.

"Trusting that the above answers the questions and that I may be useful if you are in trouble, . . ."

In a few days I received the following: "Thank you for your early reply to my letter and the extent you went into the

case. I assure you that this is greatly appreciated.

"This being my first case in which I have the misfortune to neglect interposing a filter, it was noticed immediately after the treatment was finished. I am glad to admit that my experience with x-ray dermatitis is very limited. This will probably explain the reason for writing you in the matter.

"The matter is in the hands of the. . . of . . ., who have gone so far as to file an answer. So far, it has been kept out of the papers. Believe it will be settled before going to trial.

"The patient has a healed scar over the area of treatment. She received sufficient radiation to cause a destruction of the skin, just as you said, which healed in about six weeks."

Two weeks after receipt of the last quoted letter, I was visited by the husband of the plaintiff and her attorney, and I was importuned to appear as an expert witness for them. They offered to pay me well for my services, but when I informed them that my fee would be one thousand dollars per day and expenses, payable in advance, they concluded that they did not care for my services.

This case was settled out of court, before it came to trial, for $3,800, and is another reason why we therapeutic radiologists have to pay such high rates for malpractice insurance. The insurance companies get "soaked plenty" and we have to absorb the "*quad hoc.*"

A NEW SHARP TRICK

There is something new under the sun. An eastern radiologist recently wrote me: "In an article in the May, 1935, issue of RADIOLOGY, there is a footnote in which you said that you would give advice to anyone wishing to know how to avoid having to give expert testimony after being called to the witness stand, merely to identify films. I would appreciate the information.

"I recently had an experience which exasperated me considerably. A liability case came to court, in which the defendant was bringing suit against the insurance company because of non-union of a fracture through the shaft of the tibia. The insurance company referred the patient to a country physician, whose experience with fractures was limited and whose knowledge of x-ray interpretation was *nil.* This physician in turn referred the patient to me for x-ray examination, which I made and gave a written report to him. When the case came to trial, I was subpoenaed to identify the films only and the country physician followed me on the stand as an expert witness, using my report as a basis of his testimony. The reason for such a procedure on the part of the attorney for the insurance company was twofold. First, the country physician was notorious for his ability to testify as desired by the attorney, and second, his fee as an expert witness was quite low. I would appreciate any suggestions from you, as to how I might avoid such situations in the future."

I replied: "Yours of last Saturday received. Yes, there is a footnote below my paper in May RADIOLOGY. In fact, there were several of them. If you will refer to page 567, which is the one to which I believe you refer, you will find that you did not read all of it. However, I am enclosing the instructions mentioned and trust that they may be of some use to you, as they have been to me and several others. At the end of that same paper is another footnote which I think will interest you.

"I thought that I had come upon about all of the sharp tricks of the crooked lawyers, but evidently there are some of them that I still must learn. Your recital of how they turned a country physician into an expert witness and into interpreting your roentgenograms is a new one on me. However, it should not be at all difficult to 'fix his clock.' If you have the attorneys for the other side of the case dig into his training and qualifications as an expert, it should be easy enough to have his testimony shot so full of holes that it would look like a sieve. If I had it to do, I am sure that I could have it and him torn to shreds as far as his posing as an expert.

unless he knows his stuff. By this means—of showing him up or forcing him to show himself up to the judge and jury—there should be little difficulty in having his testimony practically erased from the evidence in the case, and if the case is decided against the side you favor, his testimony of itself would be enough to produce a reversal by the higher court.

"I am unable to find anything in the cases of this sort from your State. If you will look up Sheldon *vs.* Wright, 80 Ver.R., 298; 67 Atl.R., 807, or Liles *vs.* Hannah Picket Mills, 17 S.E.R. (2nd), 233, you may find something that may help.

"As a general rule, it is becoming more and more evident that the courts are expecting roentgenograms to be interpreted by experts and it is only a question of time until this will be the rule and only those who can qualify as experts will be permitted to interpret them in court. Of course, you and I know that that is as it should be.

"I am sorry that I am unable to give you anything like definite advice in your dilemma, but I trust that the above may help."

LAYMEN AND TECHNICIANS AS EXPERT WITNESSES

In 1932 a well-known roentgenologist in New England wrote me: "May I be so bold as to call upon you for some help? Within a year in this State, on two occasions, one only a week ago, a superior court judge allowed an x-ray technician to qualify as an expert and interpret x-ray films as to the presence of fracture, this particular case being one where there was a question of skull fracture.

"The practice of medicine has not been defined in this State. Will you please tell me how to go about the hunting up of legal opinions on the qualifications of experts? Have you any material at hand that you could loan to me? Is there a law digest that might help me in this situation?

"I think the matter should be brought to the attention of our local and national societies and an extensive drive be made.

"Any help that you may give me will be greatly appreciated."

I replied: "Yours, etc., and as I am in the midst of preparing a paper which touches upon the very question you are asking about, I am glad to be able to reply so soon.

"The giving of expert testimony by technicians is becoming more and more common all over the U. S. and it is difficult to outline a plan to beat them. I have once knocked the testimony of a layman who has for years testified as an expert, by giving the opposing attorneys a list of questions in anatomy, which they should ask the offending layman. These questions were germaine to the subject to which he testified, but he was unable to answer any of them correctly, and the result of this strategy was to completely nullify what he said about the x-ray films in question. I believe that if you and your confrères would plan something of that sort, you could soon prove to the offender that it does not pay to pose as an expert.

"Your question as to whether there is a 'law digest' induces me to say that there should be one of legal medicine or medical law, but unfortunately there is none that would be of much value to us. There are, of course, numerous digests, but none of what we want and need. I have in preparation a review of 85 Supreme and Appellate Court decisions, some of which are along the lines you seek, which I expect to have published in one of the two leading x-ray magazines shortly.

"I have given the legal side of medicine—particularly of our specialty—more study than any one I know of and believe that I am in as good a position to discuss these things as any one we have. I do not say this to brag, but I believe that the older men in our work recognize this to be true.

"But to give you something more specific about your situation: Liles *vs.* Hannah Picket Mills, Inc., 17 S.E.R. (2nd), 233, is a North Carolina Supreme Court decision in which the court said: 'The testimony of a witness explanatory of a roentgenogram was properly excluded in a finding by

the court that he was not sufficiently qualified to express an expert opinion on questions of anatomy in connection with the proposed explanation.'

"You should also secure considerable material of benefit from a review of the following decisions:

Roscoe Stevens *vs.* Ill. Central Ry. Co., 134 N.E.R. An Illinois case.

Daniels *vs.* Iowa City, 183 N.E.R., 415. An Iowa case.

Ligon *vs.* Allen, 181 S.W.R., 656, 657. A Kentucky case.

Kassoff *vs.* Kupperburg, 154 N.Y. Supp., 149. A New York case.

Sheldon *vs.* Wright, 80 Ver. R., 298; 67 Atl. R., 807. A Vermont case, which is liable to be of considerable value to you as it involves just about what you want.

"I might go ahead and cite you dozens more of these decisions, some of which might give you only a line or two that would be of value; but I am sure that you will find sufficient to at least start you along the lines you seem to want.

"Assuring you that it is always a pleasure to be of use to my friends, and that I will be glad to learn how you succeed in your affair," etc.

We have little or no fault to find with the introduction and identification of roentgenograms by technicians; in fact, many roentgenologists prefer to send their technicians to identify their films; but when it comes to interpretation and the making of diagnoses, we have most strenuously objected and expect to continuously continue to object in that such practice must end.

At this time, with so much discussion relative to the roentgen diagnosis of pneumonoconiosis, is a good time to rise up in our wrath and start a campaign against uninformed laymen testifying as experts in roentgenology.

It has been our experience that cheap, pettyfogging lawyers are the most likely to employ these non-medical witnesses as experts, and a concerted action by medical radiologists along the lines indicated in the foregoing, besides seeing that leading questions regarding medical training, medical degrees (or the lack of same), membership in medical societies, special societies, etc., should go a long ways toward convincing the lawyers that their technicians' testimony is worthless and that it is useless for them to continue employing them.

Unquestionably, the lawyers who employ and make use of these non-medical witnesses and technicians who testify as experts are as much or more at fault as are the witnesses themselves. Much of this may be due to the fact that these lawyers undertake to prosecute many (if not nearly all) of the suits wherein such witnesses may be used, on a contingency basis, and as so many of such suits have little or no real merit, it is difficult to find honest, upstanding medical experts who will testify as the lawyers want them to. This is not entirely true, however, as is evidenced by a recent example in the writer's experience.

An attorney for an industrial institution recently called upon the writer and asked for interpretation of two roentgenograms. When informed that both thoraces in the roentgenograms showed findings strongly suggestive of pneumonoconiosis, he evinced definite disappointment. He said that a local technician had that afternoon testified that one of the films showed shadows produced by iron or stone dust in the lungs, and that he had hoped I would disagree with that finding. When I told him how I would attack the testimony of the technician, by discrediting him and his testimony, he responded that that would not avail or be of any benefit unless he was able to put a convincing medical expert witness on the stand who would testify that the technician's testimony was wrong, incorrect, and therefore not to be believed. Of course, I could not send him to any of that sort, because the pneumonoconiotic deposit was clear and evident in the films, and even though I knew one or two—better say several—medical men who for fifty dollars would be very likely to swear to almost anything. I told my legal friend that and he admitted that he also knew several

medical men who would give the kind of testimony he sought, but he did not want that kind of testimony from that kind of witnesses.

This phase of the situation must be handled differently, and it seems that the only feasible way it can be properly and successfully coped with is to influence the courts into understanding that only trained and properly qualified medical experts should be permitted to make diagnoses and interpret roentgen findings. They would not permit laymen or non-medical technicians to diagnose scarlet fever, diabetes, or appendicitis: then why permit these same persons to diagnose other, much more complicated, diseases or pathologic conditions? I have told judges—in conversation, out of court—that they have no more right to permit laymen to interpret roentgenograms than they have to allow them to make diagnoses of syphilis, typhoid fever, Bright's disease, or pneumonia. This has stirred up some discussion; but it has been our opinion that some of our argument would grow where it was planted. If all of us would plant that sort of seed at every opportunity, it would not be long before we would see a sprout here and there. It is by keeping everlastingly at it that we will accomplish our end. We have seen this in our long-contested claims to the ownership of the roentgenograms, which have finally culminated in a state supreme court decision along the lines that we have claimed, and advocated for many years. The road may be long and hard, and even "beset by ruffians," but right will prevail, and will win if continued effort is persistently maintained.

WAS IT INFANTICIDE? NO, THE BABY HAD NOT BREATHED!

The utility of the roentgenogram, to ascertain if an infant has ever breathed or not, has been applied a few times to determine the possible guilt of young (and older) mothers. An instance of this kind occurred in the writer's experience many years ago.

A young woman, pregnant and at term, had a very violent altercation with her husband, late one evening. He arose from the bed and the following morning was found by his wife, dead in the bath room, with the gas heater turned on.

Naturally, terribly shocked, she ran to her bed. The shock probably induced a precipitous labor, as she was found in bed with a dead baby beside her the following evening. Her husband's mother, who found her, summoned the police, and the policeman who first arrived being a patient and friend of mine, called me.

The mother-in-law, in her frantic grief over the death of her son and possibly for some other reason, suddenly screamed out that the young mother had probably smothered her baby. This charge naturally introduced a new and, to the deputy coroner, perplexing uncertainty into the situation.

The policeman, again wishing to push the writer to the fore as much as possible, asked me if I could determine whether the baby had been born alive. Not being so very backward or bashful myself, I offered to try to determine if the infant had breathed or not, and, with the consent of the deputy coroner, took the dead infant to my office, which was only a few doors away around the corner, and made several roentgenograms of the thorax of the baby. I found that the lungs were completely atelectatic and, at the coroner's inquest, reported to the jury that the child had never breathed, thus establishing the facts in the case and relieving the young mother from what looked like a possible charge of infanticide.

CONTRIBUTORY NEGLIGENCE OF PATIENT: KEEPING OF RECORDS

In 1910, a man who had been treated by a drugless healer (*quid rides?*), and had suddenly lost consciousness after a neck-wrenching application of the therapy, applied to his family physician for relief for a "stiff neck." The physician after looking the patient over directed that he come to his

office in a few days. The patient did this, and in the presence of his office attendant, the doctor directed the patient to go to my office for x-ray examination, at the same time calling me by telephone and telling me about the case.

I made a note upon my desk pad, informing my technician that I wanted to make the examination myself. The patient did not come in as per his appointment and I forgot all about the matter.

This patient deserted the treatment of the first physician and went to another, who also sent him to me for roentgen examination. This time he came and my plates revealed a fractured arch of the axis. Naturally he was put into a jury mast apparatus, which he wore for several months, and had a pretty bad time.

A few months later, this patient brought suit against the first physician for malpractice, alleging among other things that he had neglected to use the x-rays in "ascertaining the diagnosis," etc. Shortly before the trial of the case the defendant physician visited me in my office and told me about the case, and reminded me about his having called me over the telephone, making the appointment for this man to have his neck examined. I looked up my desk pad and found the notation before mentioned, and, after a conference with his attorney, who thought he might be able to introduce our telephone conversation in evidence, it was decided that I was to appear as a witness at the trial.

At the time of the trial, the defendant testified that he had directed the plaintiff to go to my office for x-ray examination, his office nurse testifying that she had heard the foregoing instructions given to plaintiff by defendant. When I was called to the witness stand, I was allowed to testify that I had had very many telephone conversations with the defendant physician, that I did what x-ray diagnosis he had done, that I could positively identify his voice over the telephone, that he had made an appointment on a certain date for me to make x-ray examinations of the neck of a certain Mr. Blank, that I had made written notes of that appointment, and that Mr. Blank did not appear at the appointed time. It was further brought out that the same Mr. Blank was sent to me by another physician and that I did examine the plaintiff for the second physician several weeks later.

Of course, the defense alleged contributory negligence, because the plaintiff failed to follow instructions and have his neck examined by the x-rays as directed, such instructions being proven to have been given by the testimony of defendant, his employee, and the writer.

The trial judge, in his instructions to the jury, directed them to bring in a verdict in favor of the defendant, *if they found that the plaintiff had contributed to his poor condition by failing to obey the defendant's reasonable instructions and directions.*

The jury, within a few minutes, brought in a verdict for the defendant physician with a judgment for the amount of his fee. Application for a new trial was denied by the judge. The case was not appealed, as this was too evidently a case of contributory negligence.

This was an interesting and unusual instance wherein the writer happened to be the roentgenologist of two physicians who had been "at daggers' points" for years, but who at that time learned the folly of their ways and became fast friends and are such to this time.

The foregoing is an important lesson on the value of making and preserving notes and records. The writer has always made copious notes and kept careful records and has advocated the value and importance of making and keeping records, so again he says, *make records at the time you do a thing and keep the records until after the act recorded has been outlawed.* We have in our files, records of examinations made more than twenty years ago of infants and small children, who, because of their age, might bring malpractice or other damage suits at any time within two years after reaching their majority. Several of these records and roentgenograms are of birth fractures, which must be kept until the patient of

whom they were made becomes twenty-three years old.

Under the title of "How Long are We Liable?"[4] the writer called attention to an instance wherein a physician had been sued for malpractice sixteen years after rendering services. This should prove to skeptics that the precautions taken and herein advocated are not at all unreasonable nor far-fetched. *Operæ pretium est.*

ESTIMATION OF r UNIT LOSS AND DEPTH DOSE TABLES

A western radiologist who was being sued for malpractice asked me for my working tables of dosage or radiation retention, and for depth dosage delivered at various depths at 140 kv. and 200 kv. My reply read:

"I use the following, based, I believe, upon Kingery's computation, and feel pretty safe in doing so because I have not yet over-dosed unless I deliberately aimed so to do. (See top of next column.)

"The following depth dose tables, like the above unit loss tables, are not original with me, though I do not know whence I received them; but it seems to me that Desjardins, of Rochester, gave them somewhere and I copied them." (See second table, next column.)

The recipeint of these tables was most profuse in his thanks, and said that he thought every radiologist who does any therapy should have both of them framed and posted at every control stand. He further said that the unit loss table was largely instrumental in his being able to convince the jury that he had not administered an excessive amount of radiation, and thereby enabled him to secure a "not guilty" in his malpractice suit.

AN UNUSUALLY THIN CRANIAL VAULT

About thirty-three years ago, while acting as police surgeon in Omaha, the writer was called to examine a prisoner who had been brought into the "hoosegow" very much under the influence of liquor. Upon trying to arouse the apparently stuporous man, it was noticed that the pupils of his eyes were unequal, and further examination gave strong suggestions of intracranial hemorrhage.

This prisoner-patient was immediately transported to a hospital and further examination disclosed a depressed cranial fracture. He was prepared for a decompression operation, and as the surgeon's trephine opening was made the patient stopped breathing, all efforts to resuscitate him failing.

All of this occurred before the patient

[4] RADIOLOGY, April, 1935, p. 500.

ESTIMATION OF r UNIT LOSS AFTER TREATMENT

Days after Treatment	Percentage Dispersed	Estimated Amount of Radiation in r Units Retained						Percentage Retained	Days after Treatment
Day	%	550	500	450	400	350	300	%	Day
1	5	522	475	427	380	332	285	95	1
2	10	495	450	405	360	315	270	90	2
3	15	467	425	382	340	297	255	85	3
4	20	440	400	360	320	280	240	80	4
5	25	412	375	339	300	262	225	75	5
6	30	385	350	315	280	245	219	70	6
7	35	357	325	292	260	227	195	65	7
8	40	330	300	270	240	210	180	60	8
9	45	302	275	247	220	192	165	55	9
10	50	275	250	225	200	175	150	50	10
11	55	247	225	202	180	157	135	45	11
12	60	220	200	180	160	140	120	40	12
13	65	192	175	157	140	122	105	35	13
14	70	165	150	135	120	105	90	30	14
15	75	137	125	112	100	87	75	25	15
16	80	110	100	90	80	70	60	20	16
17	85	82	75	67	60	52	45	15	17
18	90	55	50	45	40	35	30	10	18
19	95	27	25	22	20	17	15	5	19

RELATIVE DOSE DELIVERED AT VARIOUS DISTANCES UNDER THE SKIN

Depth below Skin	140 K.V.P. 15 in. F.S.D. 5 mm. Al Filter (Dose is 475 r)	200 K.V.P. 20 in. F.S.D. 0.5 mm. Cu Filter (Dose is 350 r)
(cm.)	(%)	(%)
0	100	100
1	98	99
2	91.5	93
3	80	87
4	76	80
5	62.3	77
7	46	56.6
10	30.8	38
15	14.4	20.7

was identified. He was immediately taken to the morgue. Postmortem examination disclosed that death was due to a depressed fracture of the left parietal bone, evidently the result of a blow on the head. The skull, particularly the parietal bones, was found to be extremely thin, and the writer casually and without definite purpose appropriated a fragment of the fractured parietal bone because of its extreme thinness.

Relatives of the dead man appeared and claimed the body, and brought a charge of murder against the policeman who had arrested the dead man, charging that he had unnecessarily slugged him with his locust club. Things looked rather bad for the policeman, as he had a reputation of being quick to use his club on recalcitrant prisoners. The policeman was bound over to the criminal court for trial on a charge of manslaughter.

At the time of the trial, the pathologist who had made the postmortem examination was ill and in bed with pneumonia and consequently unable to appear, and his autopsy protocol was introduced by the defense. Having been the first one who attended the dead man, I was called as a witness by the prosecution, and, remembering about the thinness of the skull, took the piece of the parietal bone with me, and in the course of my testimony mentioned that I had it.

After the state had finished with my testimony, the defense made me its witness and I was caused to present the piece of bone, and the defense had it introduced in evidence (as an exhibit). After I had been excused, three teachers of anatomy were caused to testify as to the very unusual and extreme thinness and unusual liability to fracture from a lighter blow than would fracture an ordinary skull, etc.

The policeman was able to produce witnesses that the dead man was fighting drunk, that he was an habitual drunkard and when in that condition became very quarrelsome and violent, and that the blow struck by him was not a hard one, and when on the stand himself, testified that it was necessary to club the man into submission.

The jury acquitted the policeman, and his family fell on the writer's neck and wept with joy because I had saved the fragment of parietal bone, insisting that I had thereby saved their husband and father from probable conviction.

To the writer, it is just a case of "away back when" honest expert testimony saved a man from undeserved punishment.

(*To be continued*)

RADIATION THERAPY IN CANCER OF THE CERVIX

By LOUIS C. KRESS, M.D., F.A.C.S., *and* M. C. REINHARD, M.A., *Buffalo, N. Y.*

From the State Institute for the Study of Malignant Disease, Buffalo, N. Y.; Burton T. Simpson, M.D., Director

MOST discussions of cancer of the cervix deal with etiology, symptomatology, diagnosis, and treatment. The first three are important, but this paper will deal entirely with the last, namely, the types of treatment which have been used at the State Institute for the Study of Malignant Disease, in Buffalo, since 1913, with a report of some of the end-results. The treatment of this disease is primarily a radiologic problem; either radium or x-ray can be applied to the cervix both externally and internally and, since the response of the tumor is in part proportional to the amount of radiation applied, the trend has been to increase the total amount of radiation delivered into the organ.

In evaluating the end-results of any form of treatment, it is customary to include only those patients who have been under observation for at least five years. Nevertheless, since radiation methods have been changing so rapidly, a consideration of the treatment of patients who have been observed for less than five years may be of value from time to time. Unfortunately, at our Clinic, a large majority of the patients are suffering from far-advanced lesions, making it even more difficult to evaluate the improvements in technic under these circumstances. In dealing with this type of material, any improvement in the immediate results would be in the nature of a gain.

An endeavor has been made to divide the therapy given at this Clinic into definite period groups:

First period—from 1919 to 1925 (1)
Second " — " 1925 to 1930 (2)
Third " — " 1930 to 1935
Fourth " — " 1935 to the present time

The technic and results of therapy in the first two periods have been published (1 and 2) and will be reviewed very briefly. The third period deals with the use of 4-gram pack applications, the protraction of the x-ray treatments, and the internal application of radium tubes and radon seeds; the last period deals with the 4.5-gram radium pack, augmented by tubes, seeds, and x-ray.

In the first period, between 1919 and 1925, treatment of cancer of the cervix was rendered by means of radon tubes, radon pack, and 200 kilovolt x-rays. In 1913, the Clinic received a donation of 50 milligrams of radium from a prominent Buffalo woman who in the later years of her live suffered from carcinoma of both breasts. During 1920, 2 grams of radium were purchased and placed in solution, and in 1921 the first 200 kilovolt x-ray machine was installed. Therefore, because of the inadequacy of the therapeutic agents at hand at that time, it is needless to report what was accomplished prior to 1919.

The surgical preparation for the introduction of the intracavitary radiation will be omitted here bcause it is quite usual and familiar to us all. A biopsy specimen was, of course, obtained from each patient. Intracavitary radiation in the form of a 50-milligram radium tube filtered through the equivalent of 1.0 millimeter of platinum was used until 1920, after which time radon tubes were used, the dosage ranging from 1,400 to 3,100 millicurie-hours.

External radiation was applied by means of a radon pack, the rays of which were filtered through 0.5 mm. silver, 2 mm. brass, 1 mm aluminum, and 1 mm rubber. The pack was placed on the anterior and posterior abdomen for 6,000 millicurie-hours to each skin area. During 1922, the square pack was replaced by a rotating pack, and the filter remained the same with the exception of the silver, which was omitted. The dosage was about 5,500 millicurie-

hours to each of two anterior and two posterior fields on the pelvis (3).

In some instances 200 kilovolt x-ray apparatus supplied the external radiation instead of the radon pack and the factors used were 200 kv., 4 ma. and 0.5 mm. copper filter, which gave an effective wave length of 0.16 Å. Two anterior and two posterior ports were radiated at a distance of 80 centimeters. In 1922, the current was raised to 8 milliampers and more external radiation was given. In about 1924, the first attempt was made to divide the total dose of x-ray into smaller increments given over a period of several days. In the latter part of the first period, the treatment consisted chiefly of radon tubes inserted into the cervix in addition to the external application of x-rays to the pelvis.

The results of this method of treatment, grouping the patients according to Schmitz (4), are as follows:

417 Cases	Percentage of Cures
Group I	62.5
" II	27.7
" III	13.2
" IV	1.1
" V	6.5

During the next five years, or second period, the intracavitary treatment was similar to that preceding it. With the introduction of the water-cooled x-ray tube, the current for the 200 kilovolt x-ray was stepped up to 30 milliamperes, and, at about the same time, gold radon seeds were introduced directly into the cervix. The technic for this combination of therapy can be briefly summed up as follows:

On the day of admission the patient received 480 roentgens, applied to the anterior pelvis. The factors were: 200 kv., 30 ma., filter of 0.5 mm. copper, field 20 × 25 cm., distance 80 centimeters. On the following morning under gas and ether anesthesia, a biopsy was obtained. The cervical os was dilated and the uterus curetted. Radon tubes of approximately 100 millicuries each with 1 millimeter platinum filter were placed in tandem in the uterine cavity and allowed to remain for an average dose of 2,400 millicurie-hours. Interstitial radiation in the form of gold radon seeds having a wall thickness of 0.3 millimeter was also used in the cervix. Seeds of from 1 to 2 millicuries were used, and the total dosage depended entirely upon the diameter of the tumor, varying from 1,600 to 2,400 millicurie-hours. If upon calculation sufficient radiation had not been administered, another dose of 480 roentgens was applied to the posterior pelvis with the same factors as those for the anterior pelvis. In order to avoid overdosing the cervical-rectal septum, it is necessary to determine the amount of radiation which reaches that point from intracavitary, interstitial, and external radiation. For the intracavitary and interstitial radiation the amount at this point was estimated by means of factors, as outlined by Mattick and Stenstrom (5). For the external radiation the customary isodose charts were used. Practical experience has shown that this area will tolerate one and one-half skin erythema doses. Often it was found necessary to repeat this cycle of radiation after three months.

Among the complications incident to these therapeutic procedures, may be mentioned the dissemination of infection as a result of seed implantation, but in our experience this is rare. Another complication is the formation of fistulæ, but when most of the cases treated are far advanced, this complication is to be expected if an honest effort is made to combat the disease.

The results from this method of treatment are as follows:

IN 1936, 955 CASES (INCLUDING THE 417 PREVIOUSLY REPORTED)

Group	I	63.1 per cent of cures
"	II	32.7 " "
"	III	17.8 " "
"	IV	1.0 " "
"	V	10.2 " "

In comparing these figures, there is a gain in Group I of 0.96 per cent; in Group II, 18 per cent; in Group III, 34.8 per cent, and in group V, 56.9 per cent. Group IV shows a loss of 0.91 per cent which is insignificant. These results show an improvement in percentage except in Group

IV, and methods must be devised by which more of those cases can be salvaged.

The purchase of an additional 5.775 grams of radium in 1930 made possible the construction of a 4-gram radium pack. The use of this therapeutic agent for external radiation played a prominent part in the therapy of cancer of the cervix during the third period of 1930 to 1935. This was a period of experimentation to establish a suitable procedure with this instrument about which little was known at that time. A description of this pack has been published (6).

Protracted radiation was coming into vogue and that, together with the new pack, necessitated that some time be spent in orienting ourselves with respect to the two. A variety of technics were used, including one large anterior and one large posterior field with a radium skin distance of 15, 20, or 25 centimeters. The last, because of the low intensity of the radiation, was found to be impractical. At the shorter distance of 10 or 15 centimeters, the amount of radiation reaching the mid-pelvis was found to be inadequate to cope with the disease.

A four-field technic was next used in order to increase the amount of radiation reaching a point at the center of the pelvis. Two anterior and two posterior fields were used, the beams inclining slightly toward the mid-line. This resulted in an appreciable gain in relative depth dose, but, because this was not enough to eradicate the disease, this pack was discontinued in 1935.

In view of the recent knowledge concerning skin tolerance, it was found that many of these patients received inadequate treatment during the period from 1930 to 1935. All of these patients, however, were suffering with far-advanced disease, being in Group IV, and it is difficult to compare the end-results with those of the two previous periods in which all of the groups were represented. It must be said, however, that some of these patients treated with the four-field technic did get a regression of the cervical lesion, but the pelvic metastases were not influenced. The intracavitary and interstitial radiation remained about the same, except that the element was substituted for radon.

The constant desire to deliver more radiation into the pelvis caused our physicist to design a new type of pack or bomb, which, according to accurate measurement, delivers 50 per cent more radiation at 10 centimeters depth than did the former 4-gram pack (7). In the construction of this pack, a method of three-field cross-firing was used. The pack was designed in order that the optimum depth intensity might be obtained in the pelvic region, and is especially adapted for use in the treatment of uterine, cervical, ovarian, bladder, and rectal lesions. The pack consists of three separate compartments each holding a tray 3×6 cm. and containing 1.5 grams of radium. A skin distance of 10 centimeters is used. The rays from three sections are directed so as to converge from 4 to 12 centimeters below the skin. The three separate fields measure 5.5×9.5 cm. with the long axes parallel. The compartments are separated from one another by 3 cm. of lead. The secondary filters at the base of the pack, which come in direct contact with the skin, are 1.0 mm. of copper and 1.0 mm. of aluminum. The base of the pack is curved so that it conforms quite well to the contour of the average pelvis.

To date, only 12 uterine patients have been treated with this pack, the reason being that the treatment consumes considerable time and the pack is used on patients suffering from cancer in other parts of the body. All of the patients thus treated were suffering from far-advanced cancer, all being in Group IV (Schmitz). Perhaps this was not a fair test, but if the results are satisfactory in Group IV, it seems logical to assume that the results in the earlier stages will be more satisfactory.

Of the 12 uterine patients who have been treated with this pack to date, seven were under 40 years of age and five were between 40 and 59 years, showing that the most favorable cases were not selected with regard to age or amount of involvement.

The pathologic grouping seemed to have no bearing on the result, as all types were encountered, from the pearl cell to the very anaplastic type of carcinoma.

Three methods were used, but the first two have been discarded and the third only is now in use. The first method consisted of 28 days of treatment, alternating anterior and poterior fields daily, so that the anterior pelvis received 14 treatments with one day intervening, and the posterior pelvis likewise. The length of treatment was 3 hours and 52 minutes, each application delivering 400 roentgens per field, each day of treatment. The calculated cumulative skin dose was 3,760 roentgens with a total tumor dose of 4,900 roentgens. The second method continued the treatment over a period of 50 days, 25 treatments anteriorly and 25 posteriorly, with a daily increment of 200 roentgens, requiring 1 hour and 56 minutes to deliver this dose to the tissues. Thus, 4,375 roentgens were delivered into the tumor with a cumulative skin dose of 3,530 roentgens. This method caused irritation to the bladder and quite a severe reaction near the trigone. Three days after completion of the treatment, the skin blistered and later peeled and tanned. The tumor was diminished after three months, but some remained; interstitial radiation was used in the cervix and intracavitary in the uterus. Last examination revealed induration in the left broad ligament area.

The remaining 10 patients were treated over a period of 20 days, with a daily increment of 500 roentgens per day which consumed four hours and 50 minutes. The details of the treatment will not be noted here, but the dosage varied between 4,900 and 5,500 roentgens in the tumor, and the cumulative dose on the skin between 3,530 and 4,090 roentgens. This, considering the varying sizes of individuals, is quite a constant average and the variation is not great.

During the first week of the treatment the patients experience nausea and vomiting, but these subside and physical improvement is noted. Skin reaction begins to appear during the last week of treatment, first being evidenced as a definite reddening of the skin, or copper color, with the formation of vesicles and desquamation, reaching its peak about two weeks after the conclusion of treatment. These skin changes are only temporary and the skin again becomes normal.

While the results from this method are in some patients satisfactory, yet the desired results of a spectacular improvement are not noted. The first treatments were given in January, 1925, and following treatment four patients are still considered hopeless, two have died, four have received some palliation but not a total disappearance of the tumor, and one is a very recent case the result of which has not been determined.

This was an experiment in patients who were suffering from a type of growth which in our experience has not responded to other types of therapy, and an effort was made to try this type of radiation, believing that 50 per cent more radiation into the pelvis would give more gratifying results. Some of the patients in this series received further radiation three or four months after external radiation; four received intracavitary radiation by means of tandem radium tubes, one had interstitial radiation in the form of gold radon seeds, two received seeds and intracavitary radiation, and one intracavitary radiation and 200 kilovolt x-ray.

This is a very small group of hopeless cases, but the effort being made to help these unfortunate individuals will be continued, not alone in the cervix cases but in the far-advanced rectal, bladder, and ovarian cases as well. Our hope is that some day a suitable method will be devised whereby more of the far-advanced group will be salvaged. No glowing results have been set forth here, but only a report of an effort being made to find out how much more radiation can be delivered to the pelvis with the therapeutic agents at hand. At the present time we know of the results obtained with the use of higher voltage, by changing the wave length of the 200

kilovolt x-ray by means of heavy filtration, but again this is impossible with the set-up at our Clinic at the present time. Perhaps someone will find out what not to do, which is often as important as what to do.

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SYPHILIS OF THE ESOPHAGUS

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SYPHILIS of the esophagus, like gastric syphilis or syphilis of other portions of the alimentary tract, presents many problems, the chief of which is probably diagnosis. Unfortunately there is little available information on this subject in the literature. While syphilis of the esophagus has been recognized for the past two centuries, there have been only occasional reports on the subject. One author states that there have been less than 100 cases reported, and of these, many are not proven or authentic. When we consider the problem from the diagnostic point of view, realizing how often it is almost impossible to prove this diagnosis, even when all signs point to this condition, it is not difficult to understand why there is such a paucity of authentic literature. Lack of confirmation of diagnosis may be attributable in large part to the following factors:

(1) No indications for operation and surgical-pathologic confirmation.

(2) Amenability to treatment.

(3) Similarity to other lesions and coexistence with them.

(4) Difficulty in securing biopsy material.

(5) Non-recognition of lesions by esophagoscopist or failure to make the esophagoscopic examination.

(6) Infrequent postmortem confirmation—the esophagus is seldom examined.

We are again confronted by the problem of very few available statistics as to the incidence of syphilis of the esophagus. There is no doubt, however, that it is an unusual disease. We know that syphilis attacks the gastro-intestinal tract less frequently than other portions of the body, with the exception of the mouth and pharynx, and is less commonly found in the

Fig. 1-*A*. First examination.

Fig. 1-*B*. First examination.

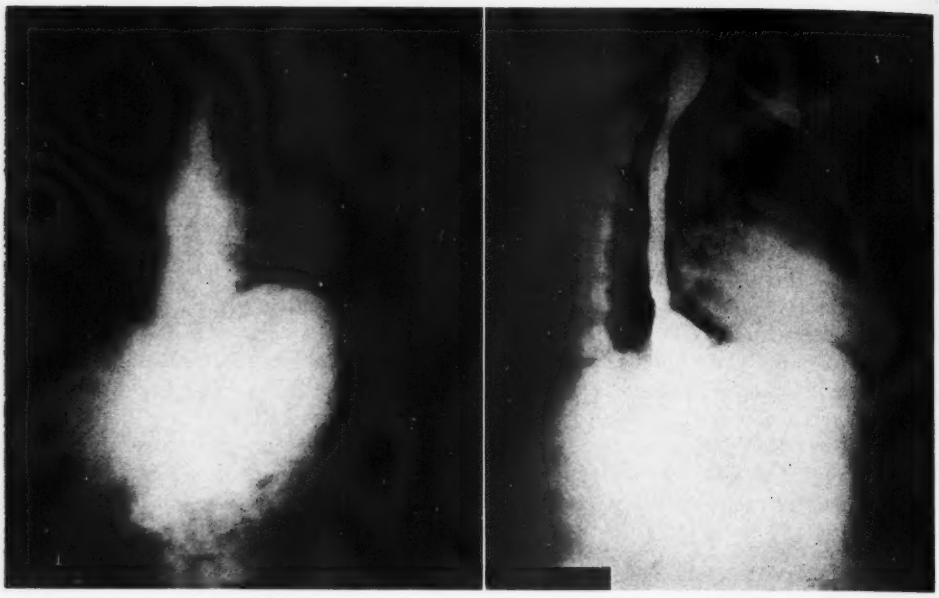

Fig. 2-*A*. Second examination.

Fig. 2-*B*. Second examination.

esophagus than in other portions of the alimentary tract. Lawrence states that syphilis of the esophagus is diagnosed as such in only one or two of every thousand cases in which lesions are present. Lukens and Ono found in the literature only 12 cases of tracheo-esophageal fistula attributable to syphilis. Another author found four syphilitic lesions of the esophagus in 350 consecutive cases of dysphagia, while still another writer claims that thousands of esophageal examinations may be made without finding a single case of syphilitic involvement. Myerson claims that from 95 to 98 per cent of all esophageal lesions in adults are carcinomas. Even though we admit that syphilis of the esophagus is occasionally unrecognized, it must still be considered a lesion, the diagnosis of which is seldom established.

The disease exhibits the same pathologic changes as those which occur in syphilis of other portions of the gastro-intestinal tract. Rarely is it in the congenital form, but it does occur. There is an esophagitis in the secondary stage often associated with mucous plaques and ulceration. We find the gumma and the contractural sclerosis in the tertiary stage. Esophagitis occurs more often in the middle half, while gummas are usually in the upper or lower thirds. There may be induration and spasm. A gumma may ulcerate and rupture. Dilatation above the lesion is usually not a striking characteristic. Sclerosis and contracture may become pronounced, with almost complete stenosis. It is to be remembered that the appearance of the syphilitic ulcer may be largely influenced by secondary infection, and may present much the same picture as tuberculous or carcinomatous ulceration. Cases have also been reported in which the lesion is primarily outside the esophagus, but the esophagus is secondarily involved.

The symptomatology of this condition is similar in many respects to other stenosing lesions of the esophagus. There are relatively no early symptoms. There may be transitory periods of dysphagia in the stage of inflammation, or esophagitis followed by periods of freedom from any symptoms. A history of transitory attacks of mild dysphagia is of the greatest

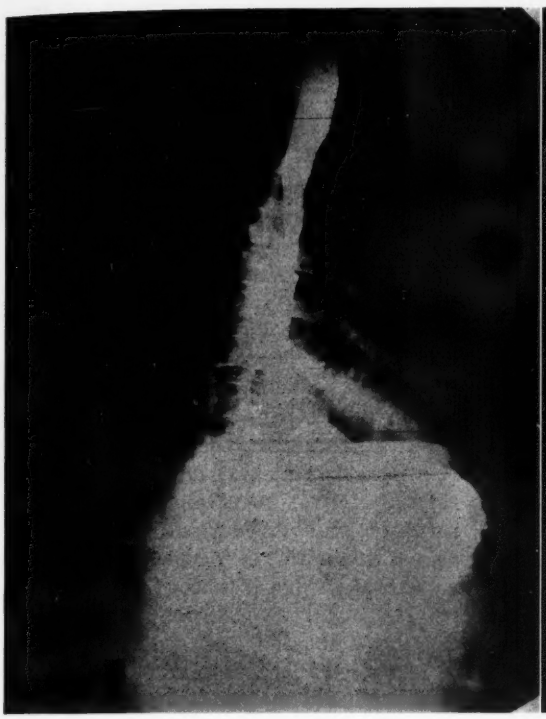

Fig. 3. First examination.

Fig. 4. Second examination.

importance in diagnosis. Patients rarely have pain though there may be some with laryngeal involvement. The onset of the dysphagia is gradual, often of from four to twelve months' duration, and dysphagia increases as stenosis becomes more advanced. The patient at first has difficulty only in swallowing solids, then semi-solids, and finally liquids. Loss of weight, anemia, and asthenia occur only in late stages and result from loss of food as well as from syphilitic toxemia.

The diagnosis is difficult. A carefully taken history is of extreme importance; it must rule out the possibility of chemical causes such as the swallowing of a corrosive, or the possibility of other trauma as a causative factor. A history of gradual painless onset, with transitory periods of dysphagia, followed by symptom-free periods is of importance. Diagnosis, while still difficult, has been facilitated in recent years by roentgen study, esophagoscopy, and serologic investigations. The x-ray examination is of paramount importance; the well trained roentgenologist will usually recognize ordinary lesions and will differentiate between carcinoma and syphilis. Esophagoscopic examination is extremely important; unfortunately, many well-trained esophagoscopists, as well as roentgenologists, have seen few syphilitic lesions of the esophagus and are unfamiliar with their appearance. It is readily conceivable that syphilitic sclerosis of the esophagus with stenosis will present no characteristic findings on esophagoscopic examination. A positive Wassermann is, of course, important, but a negative reaction certainly does not exclude a diagnosis of syphilis of the esophagus. All available diagnostic facilities must be used and the findings supported by careful history and clinical study. All other diseases to which the esophagus is susceptible must be excluded. Some of the conditions to be considered in differential diagnosis are: (1) carcinoma; (2) tuberculous ulcerations; (3) esophagitis

from chemical causes; (4) congenital stenosis; (5) cardiospasm; (6) neurologic conditions; (7) extra-esophageal and mediastinal lesions as aneurysms, tumors, and diverticula.

Prognosis is good except in advanced stenosis, being of particular importance to the patient who may be thought to have esophageal carcinoma but in whom malignancy can be excluded. Extreme contractual sclerosis and stenosis are difficult to treat. The treatment in the early stages is the same as that for syphilis. In the late stages, successful treatment can be carried out only by the esophagoscopist, when stenosis is present due to sclerosis. Direct treatment of ulcerations by the esophagoscopist is considered important by some. Esophageal dilatation is necessary in stenosis. Diet must be regulated according to the ability of the patient to take food; it may be necessary to resort to other than oral methods of feeding in extreme cases. Some patients may benefit from gastrostomy and the value of this procedure should not be overlooked. No doubt each individual patient presents a problem distinct in itself as to the course of treatment.

Two cases of syphilis of the esophagus in which the diagnosis is rather well established, are presented. The first patient was a white male, 41 years of age, a plumber by trade, who gave a history of difficulty in swallowing for the past eight weeks, the dysphagia increasing in severity until finally he was able to swallow only liquids. He also admitted that for several months he had experienced transitory attacks of mild dysphagia. One month previous to our first examination, he was treated by an esophagoscopist who dilated his esophagus. This treatment was followed by a period of severe pain and inability to swallow. He refused further treatment and four weeks later presented himself for examination. He had lost 50 pounds in weight, being able to swallow only liquids, which he vomited within five minutes. There was no history of chemical or other form of trauma to cause a stenosis.

The physical examination was negative except for the evident loss of weight. There was a mild secondary anemia, and the complement fixation reaction was four plus. X-ray examination showed a sclerosing lesion of the esophagus with almost complete stenosis (Figs. 1-*A* and 1-*B*).

Esophagoscopic examination was made and the following report given: "Narrowing at 24 inches from teeth; aperture central and $^1/_4$ inch in diameter, not irregular; fibrous and tough; no ulcerations; dilated with filiform bougie. Diagnosis: esophageal stenosis, fibrotic in character; nonmalignant, due to syphilis."

This patient was treated for a period of about nine months, the therapy consisting of repeated dilatation and systemic treatment. He was then sent in for a second roentgen study, the results of which are shown in Figures 2-*A* and 2-*B*. The man had regained his lost weight, was able to eat almost any type of food, and reported that he "felt fine."

The second case was that of a man nearly sixty years of age, sent in for esophageal x-ray examination because of difficulty in swallowing. The dysphagia had been noted at intervals for several weeks. There were no symptoms other than the dysphagia; neither was there any history of trauma, chemical or otherwise. X-ray study revealed a lesion of the esophagus (Fig. 3). The history obtained from the physician in charge of this case is of particular importance. Eight years previous to the onset of the present trouble this patient developed a condition which was diagnosed as inoperable carcinoma of the head of the pancreas. He was advised against operative interference by several surgeons in different cities. His Wassermann was negative but nevertheless he was put on active anti-syphilitic treatment, chiefly iodides and mercury. His recovery was rapid and apparently complete cure was obtained. In view of this history, the patient was again treated with iodides and mercury. Improvement was noted shortly after treatment was begun and soon the patient was free from all symptoms, the dysphagia having entirely disappeared. He

was sent into the hospital for a second study about two months following his first x-ray examination. Very definite improvement is indicated (Fig. 4). No esophagoscopic examination was made of this patient.

The two cases reported in this paper present the usual difficulties in diagnosis. The first case has a typical history of intermittent attacks of mild dysphagia over a period of months, followed by almost complete esophageal obstruction. Chemical or mechanical trauma has been ruled out and the Wassermann reaction was four plus. Malignancy and other types of lesions are rather well excluded by the x-ray and bronchoscopic examinations. The very definite improvement following dilatation and anti-syphilitic treatment is of great importance in confirming the diagnosis.

The diagnosis in the second case is a little more difficult in that the Wassermann was negative and there was no bronchoscopic examination. The history is of extreme importance; as previously stated, this man was supposed to have had an inoperable carcinoma of the head of the pancreas but made a complete recovery on anti-syphilitic treatment. Immediately after the first x-ray examination of the esophagus, the patient was again put on iodides and mercury. Improvement was rapid, so that the man was soon symptom-free. Subsequent x-ray examination confirms the clinical improvement. The amenability to treatment seems to rather definitely establish the diagnosis in this case.

SUMMARY

The literature covering the subject of syphilis of the esophagus is briefly reviewed. Comment is made concerning the absence of any large number of case reports of this disease of the esophagus. The factors are discussed which are responsible for the difficulty in establishing and confirming the diagnosis. Two cases are reported in which the diagnosis is definitely verified.

CONCLUSIONS

(1) Syphilis of the esophagus is rare; it is probably not as uncommon as is now supposed, and many cases may go unrecognized.

(2) It is difficult to diagnose.

(3) Roentgen, esophagoscopic, serologic, and biopsy examinations are important.

(4) Prognosis is important.

(5) Treatment consists of the following: anti-syphilitic; dilatation and local; dietetic.

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RADIORESISTANT EWING SARCOMAS OF BONE

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IT is frequently stated, sometimes with emphasis, that Ewing sarcomas of bone are quite radiosensitive because they usually show marked regression following irradiation. However, the use of the term "radiosensitive" to indicate mere regression following irradiation should not be encouraged, because such a usage confuses the true issue, which is complete destruction or prolonged growth restraint of malignant neoplasms by irradiation.

The large number of failures recorded for irradiation in the treatment of Ewing sarcoma are of limited significance in establishing its real value, because in the majority of cases the technics employed are now obsolete and the high mortality in Ewing sarcoma is the result of very early metastases. There are, indeed, few reports in which the neoplasm was biopsied, treated by irradiation alone, and, in the event of death, the irradiated primary tumor site examined histologically, with correlation of dosage and effects upon the tumor.

That Ewing sarcomas may be radiosensitive to the point of being destroyed or clinically controlled for long periods by irradiation alone is shown by the following reports of biopsied cases.

In addition to these cases, Bloodgood (3) cited two cases in which biopsy demonstrated the presence of Ewing sarcoma, one in the lower end of the fibula, and one in the shaft of the tibia in which local application of radium appears to have controlled the process locally for at least five and six years, respectively. Details of the amount of radium used and method of application were not given.

In contrast to the above cases, the following observations upon three patients followed in the University of Chicago Clinics are recorded. All of them died from widely disseminated metastases, and at necropsy, performed in the Department of Pathology of the University of Chicago, opportunity was afforded to study the irradiated primary tumor sites.

The physical factors in the irradiation (see below) were: 200 kv., 25 ma., 50 cm. F.S.D., 1 mm. Cu plus 1 mm. Al filtration; intensity, 38 to 42 r per minute.

In Cases II and III, a typical radio-epithelitis developed, the degree of which indicated that a maximum safe normal tissue tolerance dose had been given. In Case I, the skin was unusually resistant and accordingly more irradiation was given than in the other cases. Experience has

TABLE I

Author	Location of Tumor	Irradiation	Result
(1) Phemister (1931)	Rt. clavicle. Biopsy: Ewing sarcoma.	8 x-ray treatments at 140 kv., 2- to 3-day intervals to total dose of 5/7 "erythema dose." Two months later, two more treatments at 2-week intervals, front and back over clavicle, to total of 1 "erythema dose."	Outer 4/5 of clavicle and surrounding soft tissues removed four and one-half months after biopsy. Microscopic sections showed no tumor. Patient alive and well 9 years and 8 months later.
(2) Stewart-Harrison (1935)	Shaft of humerus with metastases (?) to scapula. Biopsy of primary growth: Ewing sarcoma.	"Protracted x-radiation" 1,300 r to anterior port and 1,300 r to posterior port. Scapula also treated but dosage was not given.	Well three and one-half years after treatment.
Same as (2)	Palatine bones. Biopsy: Ewing sarcoma.	"Protracted x-radiation": details not given.	Well 2 years and 2 months after treatment.

shown that, once a neoplasm has survived amounts of irradiation similar to those given above and which produce a severe degree of epithelitis, there is practically no possibility of destroying it by subsequent irradiation given according to any one of several technics now in vogue. Hence, the cases of Ewing sarcoma cited above exhibited practically a maximum degree of radioresistance in terms of the technic of treatment employed (modified Coutard).

Radiosensitivity is one of the most complex questions in the cytobiology of malignant tumors. The factors concerned are little or not at all understood. For a long time it was held that radiosensitivity was directly proportional to anaplasia, but experience has shown many exceptions to this rule. There are no accurate methods of determining in advance the degree of radiosensitivity of any given neoplasm. This constitutes one of the major disadvantages of irradiation therapy for operable malignant neoplasms in which there is reasonable indication that metastases have not occurred.

From experience in irradiation of malignant tumors in general, it would seem that radiosensitivity varies widely within most groups of tumors and even among any series that are histologically similar. The above studies indicate that among Ewing sarcomas there is a wide variation in radiosensitivity.

SUMMARY

Ewing sarcomas of bone exhibit a wide variation in radiosensitivity. Some may be destroyed or restrained for long periods by irradiation therapy alone.

Three cases are recorded in which the primary growths exhibited a maximum degree of radioresistance, as shown by histopathologic studies of the sites of the primary growths (obtained at necropsy) which had received maximum normal tissue tolerance doses of 200 kv. x-radiation. The common current conception that all Ewing sarcomas of bone are "radiosensitive" is not justified.

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TABLE II

Cases	Primary Growth	Irradiation[1]	Clinical Course	Histologic Findings at Primary Tumor Site (Necropsy)
I Female, aged 24 years (76,035)	Left ileum adjacent to sacro-iliac articulation. Biopsy: Ewing sarcoma.	Irradiation delivered to ant. and post. pelvic ports. 1st series: 5,100 r 2nd series: 2,500 r 3rd series: 6,380 r 4th series: 2,100 r Total 16,080 r at intervals from Feb., 1933, to April, 1934.	Died 17 months after initial series, of bronchopneumonia and widespread metastases.	Large masses of viable and proliferating tumor cells in bone and adjacent soft parts.
II Male, aged 14 years (99,562)	Seventh dorsal vertebra with adjacent soft parts invasion. Biopsy: Ewing sarcoma.	Dosage of 5,000 r to 10 × 20 cm. portal over spine. Irradiation delivered in 34 days.	Died 9 months after treatment. Disseminated metastases.	Masses of viable proliferating tumor cells in vertebra and surrounding muscles and ligaments.
III Male, aged 19 years	Right scapula adjacent to glenoid. Biopsy: Ewing sarcoma.	A total dose of 6,320 r to ant. and post. portals, 20 × 20 cm., including scapula and shoulder joint. Irradiation delivered in 29 days.	Died twelve and one-half months after treatment, of extensive disseminated metastases.	Masses of viable tumor cells in bone at primary site and extending beneath suprascapular muscles.

[1] Dosage expressed in r units measured in air (Wulf ionization chamber).

SMALL INTESTINE—INFLAMMATORY LESIONS AND ACCOMPANYING REACTIONS[1]

By LEWIS GREGORY COLE, M.D., *and* ROBERT E. POUND, M.D., *New York City*

THE subject, "Inflammatory Lesions and Accompanying Reactions," is so extensive that we thought it best to approach the discussion under four main divisions. These are apt to overlap, and, under any circumstances, should be considered merely arbitrary divisions. Your attention will be directed to these similarities as they occur. The four main divisions are as follows:

(*A*) Normal;
(*B*) Interference with motor phenomena;
(*C*) Products of inflammation;
(*D*) Reactions in certain systemic diseases.

As the radiologic technic employed in making gastro-intestinal examinations varies so widely in the hands of different physicians, it is necessary to present the normal, secured under the same technical conditions as the abnormal, in order to have an adequate control. Six ounces of a mixture of barium and water of a consistency comparable to thick cream is given on a fasting stomach. We insist upon overnight fasting as it is essential for the small intestine to be absolutely empty. The films are made at intervals which vary according to the type of case under consideration. Two very important technical factors are rapid screens and a maximum exposure time of a quarter of a second. A maximum exposure of a tenth of a second is preferable as the minor motor phenomena are so rapid that speed is demanded to secure detail. The normal rate of progress of the barium through the small intestine has a wide individual physiologic variation. Usually the head of the barium column enters the cecum within from two to four hours. The mucosal pattern and the general characteristics of the two main divisions of the mesenteric small intestine are distinctive and fairly consistent. The division of the small intestine radiologically into six distinct groups has been described before this Society and appeared in 1927 in its Journal.[2] As we may later refer to an area being in a certain group, it is wise to review this division.

A schematic drawing to illustrate this division shows groups one, two, three, four, five, and six, and a slide demonstrating these groupings in a patient.[3] Group one, duodenum; group two, consists of coils in the upper left quadrant; group three, located in the lower left quadrant. The directions of the coils in these groups is transverse, that is, across the abdomen. Group four is located in the mid-line and the coils, finger-like in appearance, with the lumen running in a vertical direction; group five is located in the right lumbar region; group six is the terminal group of coils in the lower right quadrant; in the fourth and fifth groups you will note that the direction of the lumen is chiefly vertical, although it may be a mixture of both transverse and vertical. In observing these groups, the barium passed uninterruptedly through the various coils into the cecum. There was no delay in any particular group, and the characteristics of the various segments correspond to the normal.

Interference with Motor Phenomena.—Lesions of an inflammatory character or those associated with some process which has an inflammatory reaction as a background, affect the motor characteristics of the small intestine through three different channels, namely, innervation, blood supply, and mechanics. Innervation is a term used in the broad sense and must not be

[1] Read before the Radiological Society of North America at the Twenty-first Annual Meeting, at Detroit, Dec. 2–6, 1935.

[2] The Anatomy of the Normal Small Intestine as Observed Roentgenographically, Russell W. Morse and Lewis Gregory Cole. RADIOLOGY, February, 1927, **8**, 149–153.

[3] Reference to slides shown at presentation of paper, and not to illustrations in article.

Fig. 1.

Fig. 2.

Fig. 1. Ileus. Distention and arrangement of coils is practically identical with the mechanical obstruction.

Fig. 2. Enteritis. Interference with normal motor phenomena—barium collects in segments similar to the reaction seen in the small intestine in an advanced type of ulcerative colitis.

considered as indicating a specific nerve reaction alone or a neurologic lesion. In all cases of this group there is a disruption of normal peristaltic action or muscular tone or both. Since activity and tone of smooth muscle depends upon nerve stimuli, the lack of muscular activity evidenced in all cases of this group may be associated with changes in innervation. This may be either general or local. These changes in innervation may have their origin in the central nervous system but more likely in the sympathetic nervous system. They are probably due to a toxic effect or direct pressure on Auerbach and Meissner plexuses. An allergic phenomenon might be a better term if you can explain allergy. Under this heading we have grouped ileus, migraine, enteritis, and pancreatitis.

Ileus (*Fig. 1*).—This is an atonic dilatation of the small intestinal coils with marked distention from gas and is generally considered paralytic. It may be associated with an inflammatory process in the peritoneal cavity or may be a reflex manifestation from some more remote cause. The radiologic diagnosis of ileus depends upon the appearance of the gas-filled coils seen in plain films of the abdomen. The differentiation from a mechanical obstruction, particularly when the obstructive band is in the lower coils, is very difficult and at times impossible. The presence of gas outlining the colon is more often seen in ileus than in a low mechanical obstruction; this may be due to the fact that no gas passes through the obstructive point, or that repeated enemas and insertion of a rectal tube have emptied the colon prior to the time of radiologic investigation. In some cases it is extremely difficult to determine whether or not the distention is in the large or small intestine or both. In these cases it is wise to inject only a sufficient amount of enema solution to identify the colon.

Enteritis (*Fig. 2*).—There are certain types of acute inflammatory reactions involving the small intestine and the lymphatic drainage area. The symptoms are frequently confused with an obstructive

Fig. 3.

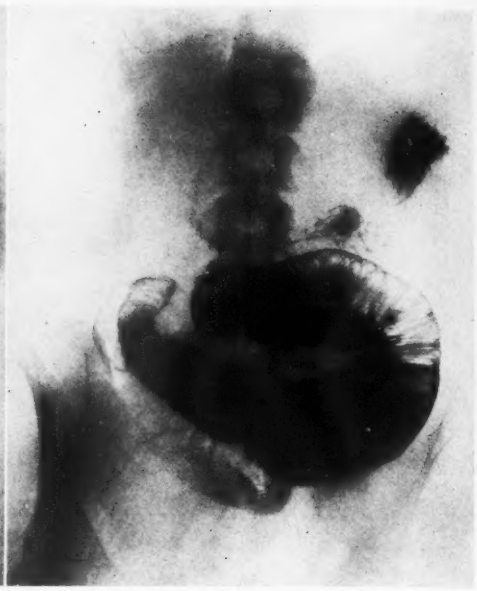

Fig. 4.

Fig. 3. Migraine. Dilatation of small intestine—diminution in major motor phenomona.
Fig. 4. Mesenteric thrombosis. Five-hour film: absence of peristalsis—stagnation of the barium in a few small intestinal loops.

lesion of a mechanical type or a peritonitis, *i.e.*, nausea, vomiting, abdominal pain, tenderness, fever, and absence of the usual diarrhea of enteritis. Roentgenographically, the findings show a very definite interference with the motor phenomena evidenced by a marked diminution in activity, a slight atony, or dilatation of the filled coils and a delay proximal to the area of greatest involvement. The amount of intestinal gas is not markedly increased, and the barium has a tendency to stagnate in segments. The plain film in such a case shows no evidence of obstruction or gas in the small intestine.[3] A considerable amount of gas is collected in the right half of the colon. At two hours following a barium meal the head of the barium column is in the second group of coils. There is a slight atonic dilatation of the filled coils. At four hours the forward progress of the barium is extremely slow, and the collection of the barium in the dilated coils is shown. At six hours all the barium is collected in a few coils in the left side of the abdomen. The disruption of normal motor phenomena is quite evident. The delay is proximal to the lower coils, and yet there is no evidence of mechanical obstruction. In this case a diagnosis of intestinal obstruction, unknown in origin, not mechanical, was made. At operation there was an acute reaction throughout the wall of the small intestine, greatest in the ileum. A moderate amount of peritoneal fluid was present and extensive lymphadenitis of the mesenteric glands. There were no bands and no mechanical obstruction. Fever continued for two weeks, then returned to normal with disappearance of clinical manifestations. Typhoid was considered after surgical visualization, but all cultures and repeated Widals were negative.

Migraine (*Fig. 3*).—The abnormal dilatation of the small intestine, with a conspicuous absence of the major and minor motor phenomena leaving only the plica circularis as an anatomic finding, was associated with this case of migraine. Did the reaction in the small intestine produce the migraine or *vice versa?*

Fig. 5.

Fig. 6.

Fig. 5. Adhesions between adjacent coils of small intestine. Note particularly the four loops in the midline.

Fig. 6. Adhesions of the small intestine to an inflammatory mesenteric node—loops radiate from the node as a central point.

Acute Pancreatitis.[5]—In acute pancreatitis one may have what appears to be an extension of the inflammatory process in the pancreas to adjacent loops of the small intestine, namely, the arc of the duodenum and the upper jejunum or second group of coils. This is evidenced by changes in the mucosal pattern, especially noticeable in the border of the duodenum adjacent to the pancreas and by variations in the diameter of the lumen which may be more or less than normal. In this film[3] the pancreatic outline is visible as it is outlined by the barium-filled stomach above and the duodenum below.

Vascular Mesenteric Thrombosis.—In mesenteric thrombosis the radiologic findings in plain films are not conclusive. There is one observation which has been present more frequently than any other, namely, lack of gas. If a plain film of a patient with symptoms of abdominal pain and accompanying clinical manifestations of obstruction shows very little or no gas, the possibility of mesenteric thrombosis should be immediately considered. The content of the lumen is usually fluid. When the loops are filled with a barium meal they show an atonic dilatation with no visible peristalsis. In this film made at five hours (Fig. 4) the filled loops are shown containing only a small amount of gas. Peristaltic activity is practically absent. At twenty-four hours there has been but little forward progress, and at forty-eight hours the barium has not passed out of the small intestine.[3] The amount of gas is increasing with the toxicity and the paralysis is more evident. We might say in passing that the diagnosis was made on the five-hour examination, but the patient refused operation by any other than her own personal surgeon. He was away and out of reach for seventy-two hours. The diagnosis was confirmed.

Mechanical.—The mechanical obstructions secondary to adhesions, which constrict the lumen by producing strictures, angulations, or rotations (volvulus), have been described, and the findings are familiar to all roentgenologists. The festooning

Fig. 7.

Fig. 8.

Fig. 7. Tuberculosis of the lower ileum and cecum. Continuous type—illustrates inflammatory changes in the wall.
Fig. 8. Tuberculosis. Skip type—numerous inflammatory lesions with uninvolved segments between.

of dilated gas-filled small intestinal coils across the abdomen in the stepladder formation is quite characteristic and denotes an obstructive or partially obstructive lesion. The difficulty lies in determining whether it is actually mechanical or whether it is one of the types previously discussed. A differential diagnosis from plain films is tricky; the history may confuse instead of clarifying the etiologic factor. The lesser degrees of manifestation of these mechanical deformities are produced by the same etiologic factors, and the symptoms depend chiefly upon the degree of obstruction to the lumen. These deformities result from adhesions between the adjacent walls of coils of small intestine (Fig. 5), between the serosa of the small intestine and some other viscus, or around the lymph nodes (Fig. 6). The involved loops may be only moderately dilated, if at all, with the mucosal pattern still present or so dilated that it is lost, and the individual loop resembles the colon. The correlation of the clinical symptoms with minor deformities is extremely puzzling and often problematical.

Products of Inflammation.—We have divided these into two main groups, those occurring outside the wall, such as adhesions, and those inflammatory reactions primarily inside of the wall, such as the lesions produced by regional inflammation and tuberculosis. The extrinsic lesions (adhesions) merge with the mechanical interference with motor phenomena, shown previously, and need not be repeated. The intrinsic ones, inside the wall, are best demonstrated by the alteration in the structure of the wall and lumen secondary to tuberculosis. In these lesions the distal portions of the ileum seem to be the site of preference. There are two main types of involvement, the isolated or continuous lesion (Fig. 7), and the so-called skip lesion (Fig. 8). In the continuous type of lesion, the lumen is narrowed, and the walls are irregularly thickened. The barium passes through the altered lumen in an irregular, narrow stream. The lumen margins are

Fig. 9.

Fig. 10.

Fig. 9. Small intestine in deficiency states—changes in the normal mucosal pattern, particularly evident in the transverse loop across the fourth lumbar vertebra.

Fig. 10. Small intestine reaction in deficiency states. Collection of barium in segments of ileum resembling a bunch of bolognas: loop in lower left quadrant shows irregularities in contour.

serrated in appearance, corresponding to the irregularities produced by the stage to which the disease has progressed. The speed with which the barium passes through the involved area depends upon the amount of local or current irritability. The adjacent normal coils appear to be displaced from the involved area, due to the thickening of the walls of the diseased portion. In this type the lesion is usually single and the area of involvement continuous. The skip lesion usually involves shorter segments, and the irregularities of the lumen again depend upon the stage of progress of the inflammatory reaction. Between the areas of local contractures there may be present areas of compensatory dilatation or relatively normal appearing lumen. These lesions may entirely encircle the lumen or may be limited to one side as shown by the absence of normal markings on the mesenteric border, and the presence of exaggerated markings on the anti-mesenteric border. In our own experience with these two types of involvement obstruction has been an infrequent complication.

Regional Ileitis (that is, Non-tuberculous Ileitis).—So far as we know we have never had an authentic case which has been proven by surgical procedure or autopsy. That it does occur we do not question, but in our own practice it is undeniably rare, either because we have failed to recognize obvious cases or there have not been any.

Reactions in Systemic Diseases with Particular Reference to the Deficiency State (Figs. 9, 10, and 11).—By "deficiency states" we refer to those conditions associated with partial deprivation of certain vitamins, of protein, and of important organic elements. Our experience lies chiefly in the reactions occurring in sprue and in the lesion generally referred to as "ulcerative colitis." In a large group of these cases in which the obvious symptomatology is referred to the colon, it was decided it might be of interest to observe what was occurring in the small intestine. It was thought that there might be some change in the rapidity of the motor

progress, which because of its speed might interfere with normal absorption and thus influence the state of obvious deficiency which accompanies the severe stages of these diseases. A very definite reaction in the small intestine was found constant in cases of the severe type. Delayed forward progress instead of increased speed was invariably present. Changes in the appearance of the mucosal markings are found from the duodenum to the cecum. The normal markings are wider—that is, thickened—and frequently bizarre in appearance. The motor phenomena are disrupted. It is perhaps much simpler to demonstrate a case of this type in which all variations in mucosal pattern and deranged motor phenomena are visible.[3] Let us say that the patient has been suffering from a severe infection of ulcerative colitis for several years. At the present time the number of stools varies from twenty to thirty *per diem*. The physiologic condition is that of an extreme deficiency state, but he is hospitalized for study rather than from necessity. A chronological study of the changes occurring in the small intestine can be demonstrated. At five minutes the second group of coils is filled and normal mucosal markings are exaggerated. At thirty minutes the head of the barium column has progressed slightly. The thickening of the circular folds of the duodenum is evident. Observe the mucosal changes in two of the lower filled loops. Note particularly the lowest loop, as your attention will be directed to this area in the four-hour film. At sixty minutes note irregular filling of various coils with exaggerated mucosal markings. At one and a half hours slow forward progress; at two hours the same bizarre appearance of the mucosal pattern; at two and a half hours most of the barium has collected in two segments in the lower left quadrant in the third group of coils. Gastric peristalsis has lessened in the last two films. At three hours no further forward progress has been made; note the isolated coil to the left of the umbilicus. At four hours gastric evacuation has again started (Fig. 10). The filled coils in the right side of the abdomen are grouped in bologna-like fashion. The diameter varies. No barium has apparently entered the cecum. The deformed loop in the lower left quadrant is the same as in the thirty-minute film. Magnification of this particular loop reveals the extent and constancy of the changes to a better degree. At six hours barium has entered the colon. The filled small intestinal loops are grouped throughout the abdomen in isolated segments (Fig. 11). At seven hours the stomach is practically empty. The diameter of the lumen of the small intestine varies throughout, with special dilatation in the lower left quadrant. The barium seems to move by segments or groups of coils.

For comparative study subsequent series are made at corresponding intervals and one is able to follow the progression or resolution of these abnormal small intestinal manifestations during the course of the disease. It would seem that as improvement occurs, or if the disease progresses, the manifestations in the small intestine should correspond. This is the rule with certain modifications. There frequently occurs a lag in either direction; that is, the clinical course may improve considerably but the small intestinal changes respond more slowly. On the other hand, the small intestinal changes may increase while the clinical course is apparently definitely improving. If this occurs, trouble for the patient is not far away, and it is a distinct warning that some complication is in the offing or a relapse is imminent. In several apparently favorably progressing cases we have had distinctly unfavorable changes in the small intestinal manifestations by which we were able to predict a relapse by means of comparative studies.

To demonstrate the improvement in the favorable progress of the disease, we shall compare the two series on the same patient made during treatment.[3] Bear in mind that the first series was made during the severe stage of the disease. The second series was made during a period of definite improvement in the clinical mani-

festations. One-hour film—first series—barium which has been evacuated from the stomach is collected in several groups of coils in the mid-line; irregular mucosal markings; lack of barium in the coils proximal and distal to filled coils. One-hour film—second series—greater evacuation of stomach; continuity of barium stream; fairly normal mucosal markings. Two and one-half hour film—first series—very little, if any, progress in the barium grouped in the coils seen in the one-hour film; gastric evaucation is beginning again as shown by barium in the duodenum; widened markings of duodenum. Two and one-half hour film—second series—gastric evacuation complete; barium progressing toward the cecum. Four-hour film—first series—puddling of all barium which has been evacuated in a single segment in the mid-line; no barium proximal or distal to filled segment; gastric peristalsis absent. Four-hour film—second series—further progress of barium; head of column in the region of the cecum; the appearance of filled coils fairly normal. At six and a half hours—first series—gastric evacuation again commencing; barium has moved out of the isolated segment into few coils distal to that area but has not entered the terminal coils or the cecum. Six and one-half hour film—second series—most of barium has entered the cecum; only a small amount remains in the terminal ileum; normal forward progress.

Thus far we have dealt with the gross appearance of the coils in their entirety. One of the reasons, and, in our own opinion, the chief reason that small intestinal lesions have not attracted greater attention, is because of the relatively small size of the lumen and mucosal markings of a local area as compared to the numerous coils and extreme length of the entire viscus. Slight variation in the normal contour and markings would, therefore, be more likely to escape detection. How many of you have recognized the presence and location of a very definite abnormal loop shown on this slide? (Fig. 9.) The lesion is clearly seen in the transverse loop directly in the midline and on a level with the fourth lumbar

Fig. 11. Small intestine in deficiency states. Irregularities in contour and variations in diameter of the lumen; diversity of size of loops dependent upon the degree of filling; peristaltic action does not result in a continuous flow of barium through the small intestine.

vertebra. The abesnce of mucosal markings along the mesenteric border with exaggeration of the markings on the antimesenteric border is clearly visible if one's attention is directed to this region. However, if the local region is magnified four or five times, the changes become as evident as the deformity of the stomach in an inoperable carcinoma. Magnifications of local areas which are involved or under suspicion of involvement will usually demonstrate the deformity to a startling degree, and is comparable to the use of a magnifying glass in the search for fissure fractures. The deformities of the cap were present from the beginning of radiological exploration of the gastro-intestinal tract, yet they escaped detection and pathologic correlation for years. At the present time the clover-leaf deformity of the cap is as symbolical of a post-pyloric ulcer as the red light is of danger. Is it not merely a question of properly directed observation? There was once a man (W. H. S.) who could never find a four-leaf clover. This upset his equanimity to no small degree, as he began to think himself a bit sluggish mentally or

addicted to extremely poor luck. So he requested from one of his friends who was always finding these lucky four-leaf clovers a handful of these prizes he could not himself find. He then gathered a box of ordinary clover leaves and mixed his handful of four-leaf ones in with these. He spent hours picking the four-leaf ones out of the mass until after a relatively short while he could separate them out with the greatest of ease. His eyes are now trained so that he can find them readily in his own clover patch. Is this not a matter of properly directed observation?

X-RAY DIFFRACTION STUDIES OF TENDON AND INTESTINAL WALL COLLAGEN

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THE x-ray diffraction patterns obtained from the fibrous proteins usually are characteristic fiber patterns but differ widely from each other in degree of perfection, depending upon the nature and relative proportions of the different amino acids of which the protein is built up. In the case of silk fibroin and keratin, a satisfactory solution of the crystal structure has been worked out from the data of the x-ray diffraction pattern. On the other hand, collagen or gelatin, being made up of some fifteen or more different amino acids of widely differing functional groups and molecular weights, previously have not given patterns with sufficient orientation and number of interferences to lend themselves readily to accurate analysis, and as a result no entirely satisfactory solution of structures has been developed. The diffraction pattern of ordinary untreated collagen or gelatin indicates the existence of long chain-like molecules which are rather easily oriented but which lack sufficient organization of their component parts of amino acid residues to produce a well-defined crystal lattice. Indeed, the existence of a halo, which shows indication of partial orientation, superimposed upon a fairly sharp interference pattern actually indicates a structure which truly may be called "pseudo-crystalline." The explanation of the lack of structural organization found in this protein is generally considered to be due to mutual attraction of the large number of polar groups which naturally must exist in such a structure. In a substance whose make-up is as complex as that of collagen in which highly polar groups must be distributed at unequal intervals in both the side chains and along the main chains, the structural design cannot be expected to conform to any definite geometric pattern but, instead, will be fashioned more likely according to the chemical nature of this material, occurring naturally in so many forms, and will yield readily to the unbalanced forces, resulting in a highly distorted structure. The interpretations of the diffraction pattern of this protein usually have been given with an effort to conform to conclusions already deduced from the mass of carefully compiled chemical data and as a result often were in direct contradiction to what few facts were actually indicated.

The practical, as well as the theoretical and biological, significance of new information on the crystal structure of collagen is readily seen from its wide use in the manufacture of leather, gelatin, glue, surgical catgut, musical instrument strings, etc. It is the purpose of this paper to describe new results of the application of x-ray diffraction technic to the study of this protein, which should throw more light upon the nature of its structure.

X-RAY SPECTRA OF UNMODIFIED COLLAGEN AND GELATIN

Although x-ray investigations of the structure of collagen and gelatin have not been so extensive in recent years, nevertheless a considerable amount of work has been done. Herzog and Jancke (15), in 1926, first attempted to assign the crystal system and dimensions of the unit cell. From their data they suggested a tetragonal unit cell of the following dimensions: $a=b=23.40$ Å.U.; $c=29.06$ (fiber axis). However, from a description of the pattern obtained nothing more than an ambiguous interpretation could be made from their results. Recent authors have made scarcely any attempt at the solution of the crystal

[1] Based on portion of thesis submitted by John A. Schaad for Ph.D. degree, University of Illinois, June, 1936.

[2] Bauer and Black Fellow, 1933–1935.

structure. However, from the usual diffraction pattern of unmodified collagen, poor though it is, several important deductions have been made. The usual pattern obtained at the ordinary sample-to-plate distance of 5 cm., employing Cu Kα radiation, consists of but few relatively sharp interferences, together with a broad amorphous halo and is essentially the same for both collagen and gelatin. A typical pattern of a well oriented collagen sample is shown in Figure 1. A brief description of the significant features of such a pattern will follow.

The innermost equatorial arc is given by a plane whose "d" value varies from 10.4 up to about 17.0 Å.U., depending upon the amount of water held by the protein. This spacing is assumed to represent the perpendicular distance between chains in the protein grid (1, 14) and may be determined to some extent by the length of the side chains. Due to the variability of this "d" value, a lateral covalent bond as postulated for keratin (5, 7) is hardly possible. The most probable structure is a salt-like linkage, as, for example, between the basic

Fig. 1.

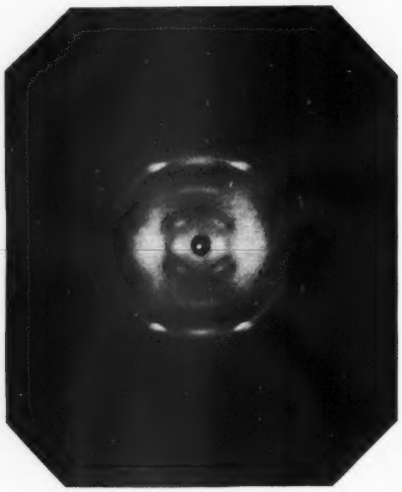


Fig. 2.

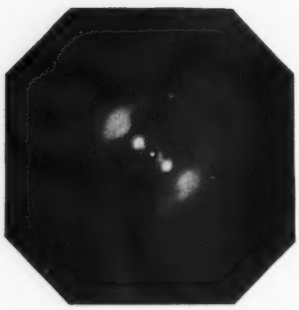


Fig. 3.

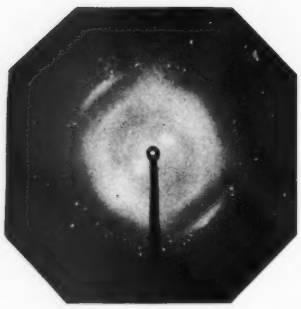


Fig. 4.

Fig. 1. X-ray diagram of unmodified tendon collagen (3 cm.).
Fig. 2. Sodium hydroxide-collagen addition compound (3 cm.).
Fig. 3. Sodium hydroxide-collagen addition compound after deswelling in a solution at the isoelectric point showing reversibility (3 cm.)
Fig. 4. Sodium hydroxide-gelatin addition compound (3 cm.).

residue of arginine and the acidic residue of glutamic acid (21, 22).

The characteristic halo corresponding to a spacing of about 4.5 to 6.1 Å.U., apparently common to all fibrous proteins, is assumed by Astbury (1, 2, 3) and others to represent the thickness of the protein chain or grid. In this lateral direction the chains are assumed to be held together by secondary valence forces only (3, 21, 25).

A rather intense meridianal arc of about 2.84 Å.U. is always found, which never approaches a circular spot even in the most perfectly oriented specimens. Although much shorter than the theoretical, Astbury and others (1, 4, 14, 17) have assumed this spacing to be the length of one amino acid residue. Some investigators have described this plane as being perpendicular to the fiber axis (diatropic) (12), whereas others have realized that it can be only a pseudo-diatropic plane (17) and therefore the real residue length must be somewhat longer. Heringa and Kolkmeyer (13) believed this plane to be tilted at an angle of 86° or 87° instead of 90° to the fiber axis. Others have described the long arc length as being due to a sort of a spiral or folded (20) arrangement of the chains or micelles.

Four symmetrically located spots given by a diagonal plane form a distinct layer line corresponding to a fiber identity period of about 9.75 Å.U. (14, 25), or approximately three times the length of a normal amino acid residue. Astbury, in explaining this identity period, preferred to use the value of 3×2.8 or about 8.4 Å.U. (1, 3) instead of the value of approximately 9.75 Å.U. as obtained by other investigators (12, 14, 15, 17, 24, 25, 26). Katz (18) noted this discrepancy but offered no explanation for it.

To account for the partially oriented halo shown in collagen fibers and stretched gelatin, Gerngross, Hermann, and Abitz (12) suggested that the protein chains forming a micelle were not of uniform length and that the apparent amorphous component represented the frayed ends of these chains. These same authors later suggested the possibility that some amino acids may form the so-called "fringed ends" and others, of a different nature, the body of the main chain (14). Other investigators (17, 25) have held similar views.

Gelatin, being the hydrolysis product of collagen, is generally considered to be made up of fragments of the partially broken down collagen micelles or crystallites. The diffraction patterns of collagen and gelatin have been compared by several investigators but with the exception of a recent work published by Clark, Parker, Schaad, and Warren (9) using special technic, no significant differences have been noted. In this work was reported the presence in collagen (surgical catgut) *but not in gelatin* of a very long meridianal spacing of about 440 Å.U., and an equatorial spacing of 48.0 Å.U. In a later publication Wyckoff, Corey, and Biscoe (27), using tendon collagen, obtained a value of 330 Å.U. for the long meridianal spacing but reported no long equatorial spacing at all.

Thus it can be seen that our knowledge of the crystal structure of this protein obtained from patterns of the unmodified material is as yet very fragmentary and not at all satisfactory. This fact suggests the thorough study of the structure of the derivatives or addition compounds of collagen or gelatin as a possible source of additional information on the structure of the original material.

ALKALI ADDITION COMPOUNDS OF COLLAGEN

Action of Sodium Hydroxide upon Collagen.—During the investigation of the swelling action of solutions of strong alkalies upon tendon collagen it was found that an entirely new diffraction pattern was produced with alkalies of a certain minimum concentration. Collagen fibers, upon treatment with dilute sodium hydroxide, undergo strong lateral swelling with a relatively small decrease in length, the effect increasing as the alkali concentration is increased. The new compound formation as revealed by the fiber pattern was found to appear after a 24-hour swelling period in 0.2 N sodium hydroxide. However, at this concentration only a partial transforma-

tion was affected and it was found necessary to increase the value up to about 0.4 N in order to obtain a clear-cut pattern. Concentrations above 0.5 N were found to be unsatisfactory as decomposition was too rapid.

That the product of the reaction between a strong alkali and collagen may be called an addition compound seems to be justified by the similar reaction of concentrated sodium hydroxide with cellulose and chitin, two somewhat analogously constructed compounds. Sodium hydroxide of mercerizing strength produces a very definite change in the crystal structure of cellulose, in which case the change appears to be definitely in the direction of a more stable structure as all attempts to revert to the original have not been successful (8, 16). In the case of chitin, also, a very definite modification is obtained, but it apparently is reversible (10). In the present case of collagen the process appears to be a reversible one, since subsequent treatment in a solution whose *p*H is approximately that of the isoelectric point of the protein causes a rapid subsiding of the swelling to about the same degree as that shown in distilled water.

Preparation of Sample for X-ray Analysis.—The sample used was selected from the tendon of Achilles of an ox. After 15 minutes extraction with boiling ether it was dried and placed in a 0.4 N NaOH solution at room temperature. Although swelling appeared to have reached a maximum after a period of three hours, the sample was allowed to remain in the solution for approximately twenty-four hours to insure rather complete swelling. At the end of this period the fibers had swollen to such an extent that they were quite transparent. Then, without removal by washing of the alkali, the fiber bundle was securely clamped at either end with steel clips and hung up. A 1.5 kg. weight was suspended from the sample and under these conditions several hours were allowed for drying. Although not necessary in the formation of the new structure, a certain amount of tension during drying is very desirable since a much sharper fiber pattern is obtained. The sample then was x-rayed in the usual manner with filtered copper Kα-radiation at a film distance of 3 centimeters. The diffraction pattern is shown in Figure 2.

Crystal Structure of the Sodium Hydroxide-collagen Addition Compound.—The reproduction clearly reveals a very well developed fiber pattern showing a degree of perfection exceeding by far that of any other modification of collagen yet reported. By the usual methods of analysis of x-ray fiber patterns the solution of the crystal structure is readily obtained. From a visual observation of the pattern there appears to be three layer lines shown by the addition compound. The value of the identity period along the vertical crystallographic axis shown by these lines as calculated from the equation

$$C = \frac{n\lambda}{\sin 2\theta \cos \psi}$$

(11) was found to be 6.50 Å.U. Since the reproduction shows that there is superimposed upon the pattern of the addition compound, that of the original structure in which the fiber identity period along the vertical axis is 9.75 Å.U., exactly three halves times the value of that of the addition compound, the possibility at once suggests itself that the reaction may be complete and that both periods and patterns belong to the same crystal structure. If this were true then the common identity period along this axis would necessarily be 19.50 Å.U. However, as is shown later in the discussion of the addition compound formed with potassium hydroxide, the 9.75 Å.U. period belongs only to the unchanged material and the three halves relationship between it and that of the addition compound is probably only coincidental. Furthermore, for an alkali-swollen fiber in which great care has been taken to insure a nearly complete reaction by occasional kneading of the plumped fiber, the 9.75 Å.U. identity period of the original material is found to be very weak.

From the measured interferences of the pattern the structure was found to belong

to the orthorhombic system with the following unit cell dimensions: $a = 5.32$ Å.U.; b (fiber axis) $= 6.50$ Å.U.; $c = 11.90$ Å.U. In Table I are given the data for all the interferences indexed. The number of the layer line is given by the Roman numeral and the position of the spot on the layer line beginning at zero for the center and going out is given by the subscript. All interferences falling on the equatorial line are designated by the letter A. The intensity of each spot was estimated and is designated by the following notation: s = strong; vs = very strong; m = medium; w = weak; vw = very weak.

TABLE I

Interference	Intensity	"d" Measured Å.U.	"d" Calculated Å.U.	Indices
A_1	vs	11.80	11.89	001
A_2	m	5.32	5.32	100
A_3	w	2.98	2.98	004
A_4	vw	2.68	2.66	200
A_5	vw	2.38	2.38	005
A_6	vw	1.98	1.98	006
A_7	vw	1.77	1.77	300
I_1	m	2.68	2.70	014
I_2	m	2.48	2.46	210
I_3	s	2.38	2.41	114
I_4	m	2.23	2.24	015
I_5	s	2.10	2.09	213
I_6	w	1.89	1.90	016
II_1	vs	2.78	2.78	120
II_2	m	2.68	2.70	121
II_3	m	2.47	2.51	122
II_4	m	2.19	2.19	024
II_5	m	2.08	2.06	220
II_6	m	2.01	2.03	124
II_7	m	1.92	1.92	025
III_1	w	1.87	1.90	132
III_2	m	1.73	1.75	034
III_3	m	1.67	1.68	230
III_4	m	1.64	1.66	134
III_5	m	1.60	1.60	035

A comparison of the calculated and measured values of "d" shows excellent agreement between the two. Furthermore, the "row lines" of a pattern indexed from the values of Table I prove beyond any doubt that the crystal system and unit cell dimensions are correct. Taking the b length of the cell to be 6.50 Å.U., which is approximately the length of two acid residues, the unit cell then is found to contain two amino acid residues.

A density determination of the air-dried, sodium hydroxide-treated sample gave a value of 1.372 g./c.c. From this value, and with the assumption of two amino acid residues per unit cell, the mean molecular weight of the acid residue of the alkali addition compound was calculated as follows: Mol. wt. = volume × density/absolute mass of hydrogen atom × number of molecules per unit cell =

$$\frac{(6.50 \times 10^{-8} \times 5.32 \times 10^{-8} \times 11.9 \times 10^{-8}) \times 1.372}{1.65 \times 10^{-24} \times 2} = 170.$$

The value of 170 is very large compared with the value of 96 as calculated for the mean residue weight of the amino acids found in gelatin (6). However, this discrepancy is accounted for when one considers the fact that not only are the charged centers of the protein highly hydrated but a considerable amount of sodium hydroxide also must be present.

In order to obtain a rough estimate of the amount of alkali taken up by the protein lattice in the formation of the addition compound, an ox tendon fiber weighing about two grams was allowed to swell in a measured volume of a standard solution of sodium hydroxide. The flask containing the solution and the sample was sealed tightly during the swelling period to prevent the absorption of carbon dioxide. At the end of two days the fiber was removed from the solution and the amount of alkali taken up was calculated from the volume and concentration of the solution remaining. The following data show the weight in grams of sodium hydroxide taken up by 100 grams of collagen at two different concentrations. (The weight of collagen is based upon the weight after drying at 110° C. to constant weight.)

Concentration of NaOH	g. of NaOH taken up by 100 g. of collagen
0.1955 N	9.13
.4680 N	51.30

Assuming the mean molecular weight of the amino acid residue to be around 100, then at the lower concentration the data show that approximately one molecule of alkali is taken up for every four or five

amino acid residues. It is at this concentration that the pattern of the addition compound first appears. At the higher concentration it is seen that slightly more than one molecule of alkali is taken up for each amino acid residue. Inasmuch as a certain amount of alkali necessarily must be held by capillary attraction in the fiber bundle, the highest combination ratio between the alkali and the amino acid residue is probably very nearly 1:1. In view of these results the value of 170 for the mean molecular weight per acid residue under these conditions is not at all unreasonable.

If the atomic radii of the carbon and nitrogen atoms are taken to be 0.77 and 0.70 Å.U., respectively, and the interbond angle of the aliphatic carbon atom to be 109°28′ (actually it is probably somewhat less in aliphatic chain compounds) and that of the N atom slightly less, the theoretical length of each normal amino acid residue should be about 3.5 Å.U. In the case of silk fibroin this value is almost realized, whereas in β-keratin it is found to be somewhat less, about 3.4 Å.U., presumably because of the distorting effect of heavy side chains. Astbury, in describing the spectrum of unmodified collagen, has assumed the interplanar spacing value of 2.8 Å.U. to be its amino acid residue length (1). Since this value is far shorter than the theoretical and does not approximate any submultiple value of the true identity period of 9.75 Å.U., this interference must be explained in some other manner. The assumption of two amino acid residues per unit cell length of 6.50 Å.U. in the sodium hydroxide addition compound of collagen gives a single residue length of only 3.25 Å.U. However, this value is well within reason when it is considered that approximately 30 per cent of the total amino acids in collagen are either proline or hydroxyproline, the residues of which due to the five membered ring structure in each, must be at least 0.25 Å.U. shorter than the length of a normal fully extended residue. Furthermore, the double residue length is in perfect harmony with the accepted theory of the peptide chain structure in which there is assumed to be a twofold screw axis of symmetry of both the carbonyl and imide groups. In the construction of models or diagrams of fibrous protein structures the carbonyl and imide groups of protein chains of two adjacent grids are usually located opposite each other. Although this is a natural deduction from the idea of mutual attraction between the two groups, the x-ray spectrum of the alkali addition compound gives no indication that the unit cell should have a depth of two acid residues.

The diffraction data are not yet sufficiently complete to undertake the establishment of the proper space group, the chief difficulty lying in the fact that low orders of many of the most important interplanar spacings are obscured by the halo of the pattern of the original material which seems always to persist.

Perhaps the most important question now to be answered concerns the exact location and mode of combination of the alkali in the lattice of the collagen crystallite. The appearance of additional interferences upon swelling in sodium hydroxide followed by drying may be due to a neutralization of certain polar forces within the lattice, thus allowing the structural units of the protein to assume a more definite geometrical arrangement, the alkali serving only to support the diffracting units in their proper places and itself not directly contributing to the diffraction. However, the large amount of sodium hydroxide taken up, approximately one molecule of sodium hydroxide per amino acid residue, strongly suggests that the alkali takes up a very definite position within the protein crystal lattice and itself may contribute most to the diffraction. From a consideration of a single amino acid residue, it is theoretically possible that a carbonyl group adjoining an imide group may give rise to an acidic residue through enolization and in this manner combine with a molecule of alkali. The alternative is that the alkali is held merely by co-ordination at some position within each amino acid residue. At any rate, the alkali appears to be bound quite firmly since a fiber swollen in such a manner will

dry readily in the ordinary atmosphere without the formation of any appreciable amount of sodium carbonate as revealed by the x-ray diagram.

Reversibility of the Sodium Hydroxide-collagen Addition Compound.—The peculiar structural effect produced in collagen by swelling in sodium hydroxide is easily re-

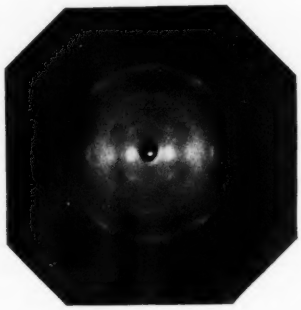


Fig. 5.

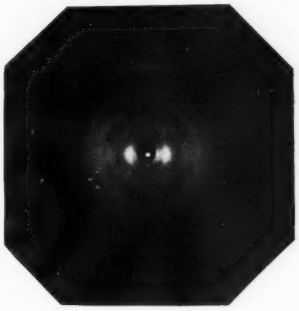


Fig. 6.

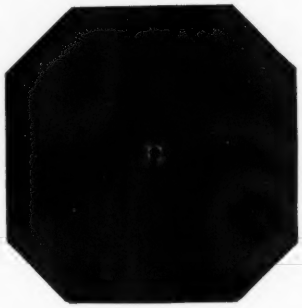


Fig. 7.

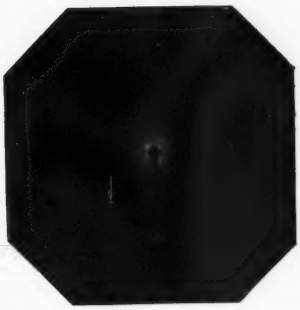


Fig. 8.

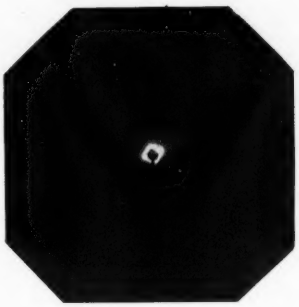


Fig. 9.

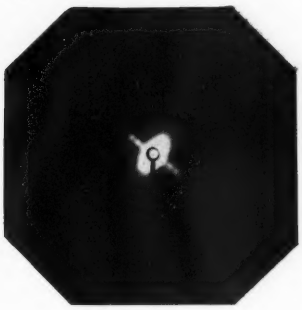


Fig. 10.

Fig. 5. Potassium hydroxide-collagen addition compound (3 cm.).
Fig. 6. Lithium hydroxide-collagen addition compound (3 cm.).
Fig. 7. Catgut suture. Taken in vacuum (10 cm.).
Fig. 8. Same sample as shown in Figure 7. Taken in air (10 cm.).
Fig. 9. Untreated tendon collagen showing various orders of long meridianal spacing (29.5 cm.).
Fig. 10. Sodium hydroxide-collagen addition compound showing long meridianal spacing (29.5 cm.).

versible. When a fiber swollen in the usual manner in 0.5 N alkali is placed in a buffered solution whose *p*H is approximately the same as the isoelectric point of the protein, namely, 4.78, a very rapid subsiding of the swelling takes place and after a period of a few hours the swelling amounts to little more than that shown by a fiber swollen in ordinary distilled water. After drying under tension in the usual manner, the x-ray pattern is seen to be exactly the same as that given by unmodified collagen. The diffraction pattern is shown in Figure 3.

Action of Sodium Hydroxide upon Gelatin.—Ribbons of well-oriented gelatin upon swelling in 0.5 N sodium hydroxide under similar conditions failed to show any such well-oriented structures in their x-ray diagrams (Fig. 4). Upon the patterns faint but sharp arcs were seen which indicated the same addition compound as that shown with collagen. The gelatin strips were dried under a small amount of tension which evidently was sufficient to line up the crystal particles or micelles themselves as shown by the well-defined 001 interference. However, it seems that the tension which can be applied to a swollen gelatin fiber is not sufficient to hold the individual protein chains in alignment. This phenomenon seems to be strong evidence in support of the theory that in collagen the micelles are linked together across their ends by some sort of binding force which gives the fibers their tensile strength.

Addition Compound with Potassium Hydroxide.—A similar compound is formed by the action of potassium hydroxide upon collagen. In this case the resulting crystal structure of the compound is much different from that formed with sodium hydroxide due perhaps to the difference in size of the two alkali metal ions. In Figure 5 is shown the x-ray pattern of the potassium hydroxide addition compound. Since there are but relatively few interferences on the equatorial line and only one layer line is present, an entirely satisfactory solution of the structure cannot be made. A careful study of the equatorial interferences indicates that the system is monoclinic, with the following unit cell dimensions: $a = 4.28$ Å.U.; $b = 3.78$ Å.U.; $c = 14.1$ Å.U.; $\beta = 59°45'$. Of some significance is the fact that the identity period along the b (fiber) axis was found to be 3.78 Å.U., as compared to 3.25 Å.U. of the sodium hydroxide compound. Although this fact is probably connected in some manner with the difference in size of the two ions, no conclusive explanation can yet be given.

Addition Compound with Lithium Hydroxide.—Of the three alkali addition compounds of collagen, the lithium compound seems to be by far the most difficult to prepare. Atmospheric carbon dioxide must be excluded during drying to prevent the formation of lithium carbonate. The pattern of the compound is shown in Figure 6. No attempt at the solution of the crystal structure is given, although it is manifestly different from both the preceding addition compounds.

ACTION OF HYDROCHLORIC ACID UPON COLLAGEN

Samples of tendon collagen were treated with increasing concentrations of hydrochloric acid up to the point at which rapid decomposition was produced. Swelling in this case was only moderate as compared to that obtained with alkali solutions of the same strength. The diffraction pattern of the dried material failed to show any evidence of a new structure.

STUDY OF THE LONG INTERPLANAR SPACING FOUND IN COLLAGEN

For the x-ray investigation of organic materials which show interferences from interplanar spacings of not more than 50 Å.U., the usual technic with the Kα-radiation of copper at a sample-to-plate distance of 5 to 10 cm. is found to be quite satisfactory. For spacings above this value the interferences are located so close to the central spot that it is always difficult if not impossible to resolve them from the trace on the film of the undiffracted primary beam. Inasmuch as the value of sin θ varies di-

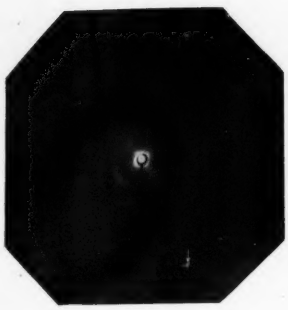


Fig. 11.

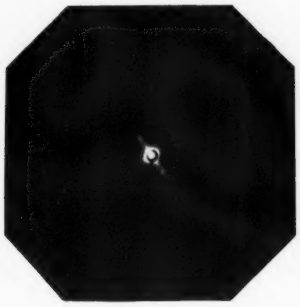


Fig. 12.

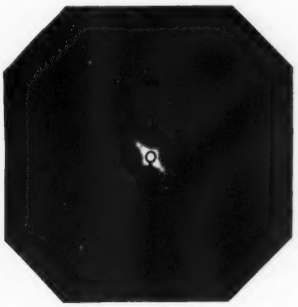


Fig. 13.

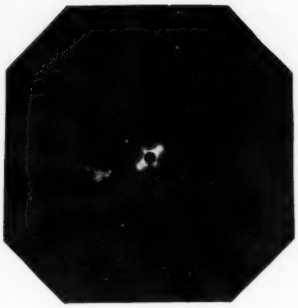


Fig. 14.

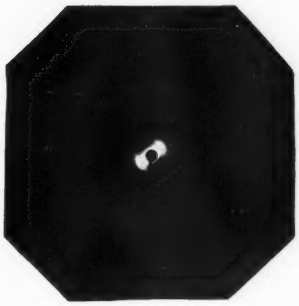


Fig. 15.

Fig. 16.

Fig. 11. Untreated surgical suture allowed to dry under no tension (20 cm.).
Fig. 12. Sample same as shown in Figure 11 but allowed to dry under 500 g. tension (20 cm.).
Fig. 13. Sample same as shown in Figure 11 but allowed to dry under 1270 g. tension (20 cm.).
Fig. 14. Extended intestinal wall collagen ribbons. X-ray beam perpendicular to fiber axis and parallel to plane of ribbons (10 cm.).
Fig. 15. Same sample as shown in Figure 14. X-ray beam parallel to fiber axis (10 cm.).
Fig. 16. Intestinal wall collagen wax extracted with hot alcohol (10 cm.).

rectly as the value of λ for any given spacing, the use of long wave length radiation such as the Kα of aluminum or magnesium usually is resorted to in such cases. The chief disadvantage of the use of long wave length radiation is that it is readily ab-

sorbed, necessitating long exposure times and the use of very thin specimens. Also, specially built gas type x-ray tubes are usually necessary.

X-radiation of only moderate wave length such as the Kα of copper can be used for the study of long interplanar spacings only by increasing the specimen-to-film distance and observing great precautions to overcome inherent difficulties in technic.

To avoid scattering due to air, especially at film distances in the neighborhood of 30 cm., a special type of vacuum camera with a variable sample-to-plate distance was designed and built. The details of the apparatus will be described elsewhere. With this apparatus it was found that not only was the exposure time greatly reduced but the interferences always were much sharper. In Figures 7 and 8 are two diffraction patterns of the same sample of raw catgut material, one (7) taken in a vacuum and the other (8) taken in air, at a film distance of 10 cm., in which a very pronounced improvement due to the vacuum can be seen. For longer distances, especially at 30 cm., a tremendous improvement can be seen.

In addition to the usual diffraction pattern shown at 5 cm., described at the beginning of this article, tendon collagen shows various orders of a very long meridianal interplanar spacing which has previously been mentioned (9). In Figure 9 is shown a typical pattern given by a bundle of untreated rat tail tendons at a film distance of 29.5 cm., using two 0.005 in. pinholes. This particular pattern shows four distinct orders, whose "d" values were calculated to be 202, 107, 72.6, and 57 Å.U. The first interference listed, although very definitely present, was difficult to measure accurately on account of its nearness to the central spot. Basing the calculations upon the third interference which is sharpest and most accurately measured, it can be seen that these values represent either the first, second, third, and fourth orders of a 216 Å.U. spacing, or the second, fourth, sixth, and eighth orders of a 432 Å.U. spacing. Other patterns of collagen at shorter film distances show still higher orders which can be accounted for only by assigning odd order values and for this reason 432 rather than 216 is assumed to represent the real interplanar spacing. It is not impossible for the actual value of the spacing to be even some higher multiple of 432 Å.U. Other forms of collagen, such as raw skin, tanned leather, bone collagen, etc., all show this long repeating unit along the fiber axis. On the other hand, the diffraction pattern of gelatin, even the very best grade in which there is no evidence of lower decomposition products, shows no long spacing whatsoever.

Effect of Chromicizing.—Repeated measurements and comparisons of the x-ray diagrams of raw and chromicized catgut indicates that chromicizing always tends to shorten slightly (for example, to 408 Å.U.) the length of this spacing.

Effect of Hot Water and Concentrated Acids, Alkalies, and Salt Solutions.—The action of hot water upon collagen is most peculiar. At room temperature water molecules are able to penetrate the lattice with ease, giving rise to intra-micellar swelling as shown by the increase in the "d" value of the 001 planes. This swelling effect is easily reversible, the lattice dimension being a direct function of the amount of water present. The long spacing is not destroyed by this process, as it appears again after drying. It has not been found possible to observe any variation in the value of the long spacing with swelling. As the temperature is increased to around 70° C., the fibers undergo a rather sudden contraction in length. The x-ray pattern of the fiber dried in this shriveled state is found to be identical with that of unstretched gelatin, showing that the contraction effect is not accompanied by a destruction of the micelles as units but, instead, only throws them into a disorganized state. Upon swelling the dried contracted fiber and drying again under a small amount of tension the x-ray pattern again shows almost perfect fibering *but no evidence of the long meridianal spacing.*

Sodium hydroxide of 0.4 N strength such

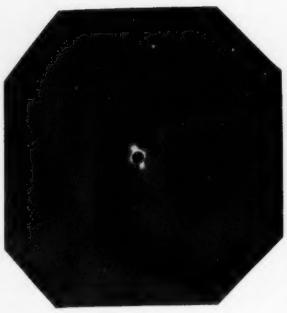


Fig. 17.

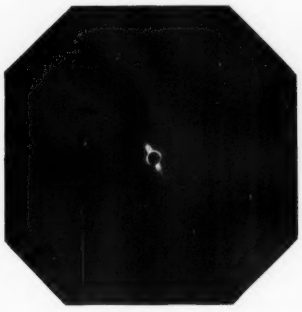


Fig. 18.

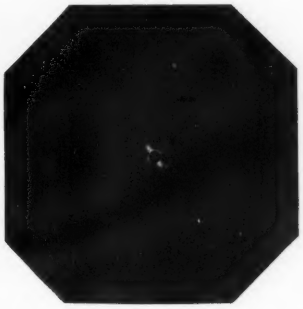


Fig. 19.

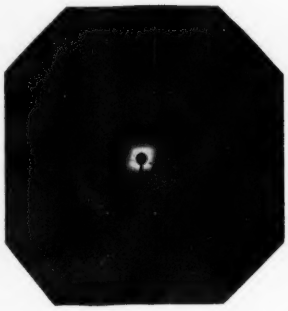


Fig. 20.

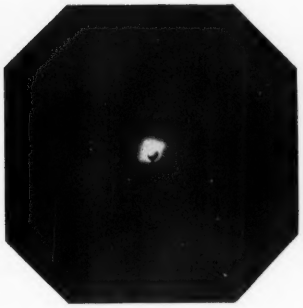


Fig. 21.

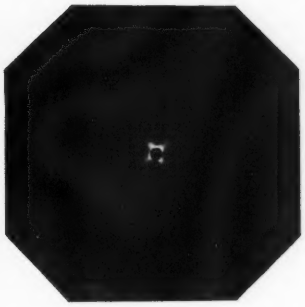
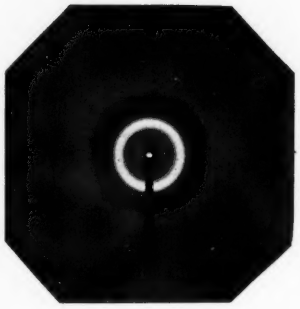


Fig. 22.



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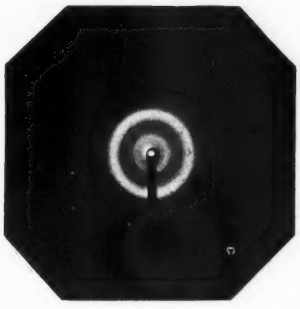

Fig. 24.

Fig. 17. Catgut suture after refluxing with benzene (10 cm.).
Fig. 18. Catgut suture after refluxing with petroleum ether followed by heating at 110° C. (10 cm.).
Fig. 19. Same sample as shown in Figure 18 but subsequently swollen in distilled water and dried (10 cm.).
Fig. 20. Fresh raw intestinal wall collagen after cleaning and drying (10 cm.).
Fig. 21. Same sample as shown in Figure 20 subsequently treated with 0.25 N NaOH, washed and dried (10 cm.).
Fig. 22. Same sample as shown in Figure 20 but swollen in strong NaCl solution followed by washing with Na_2CO_3 solution (10 cm.).
Fig. 23. Untreated tendon collagen, x-ray beam parallel to fiber axis, showing Br absorption edge from 001 plane given by general radiation from copper target (5 cm.).
Fig. 24. Same sample as shown in Figure 23, x-ray beam parallel to fiber axis, showing same Br absorption edge from 001 plane given by general radiation from chromium target (5 cm.).

as was used in studying the addition compound does not greatly affect the long fiber period provided the temperature is kept low. Moreover, fibers treated with alkali of this strength give diffraction patterns with a large amount of scattering *along* the equa-

torial line in the region of about 100 Å.U. and up. In Figure 10 is shown the pattern of the NaOH addition compound at a sample-to-plate distance of 29.5 centimeters. In this illustration the second, fourth, sixth, and eighth orders of the long meridianal

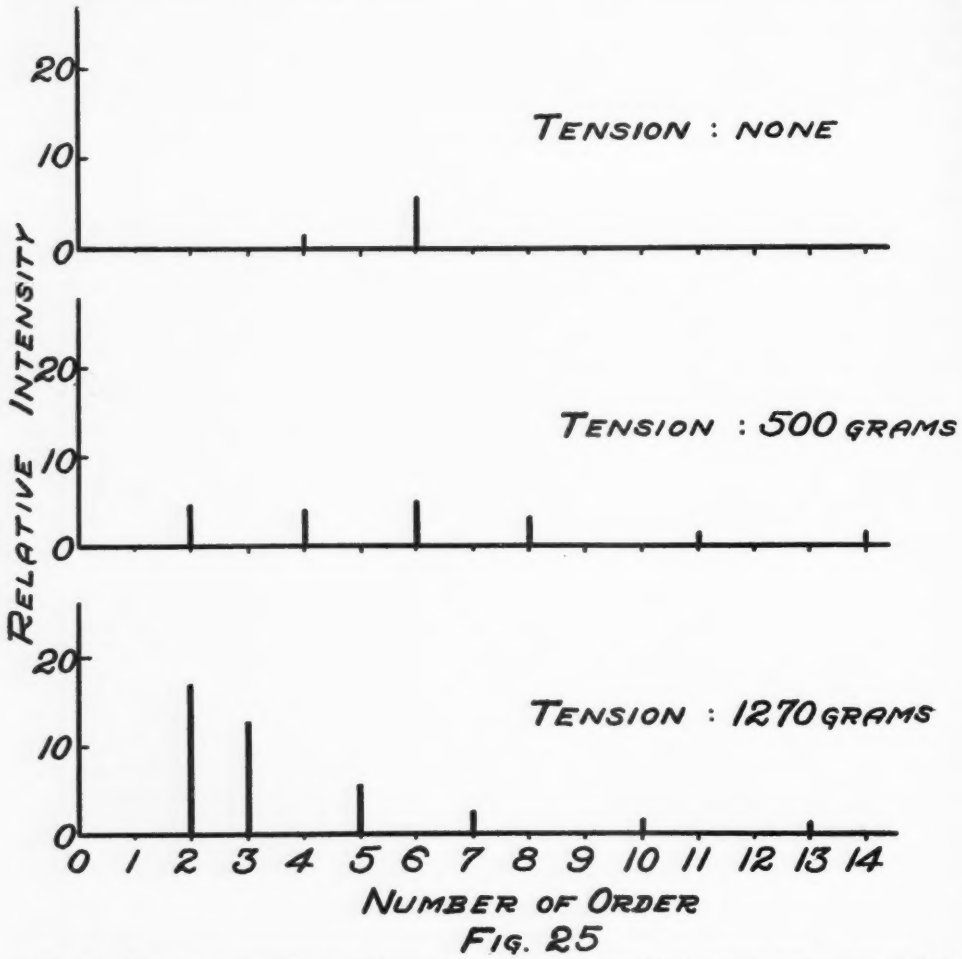

Fig. 25. Variation in intensity of different orders of the long meridianal spacing produced by drying fiber under different amounts of tension.

spacing as well as heavy equatorial scattering can be seen. This horizontal blackening at a very small angle is similar to that obtained for cellulose, etc., and is quite significant in that it indicates the existence of a long lateral spacing with a "d" value which is not constant. More concentrated alkalies and acids cause a great amount of contraction even at room temperature. The x-ray patterns of collagen contracted in this manner show that the long spacing has been destroyed.

Concentrated salt solutions such as lithium thiocyanate and calcium chloride were found to act very rapidly, especially upon tendon collagen, resulting in the complete destruction of the long spacing. In all cases cited above in which much contraction occurs, the destruction of the long spacing always is accompanied by a very great loss in tensile strength.

Effect of Drying under Tension.—Drying

of the water-swollen fiber under various amounts of tension was observed to have a singular effect upon the x-ray diffraction pattern of an untreated surgical suture. In Figures 11, 12, and 13 are shown patterns of the same material swollen in distilled water for a period of three hours but dried under different loads, namely, 0.0, 0.500, and 1270 g., respectively. The last value was found to be very near the breaking load of the particular gut used. Considering only the meridianal arcs given by the long spacing along the fiber axis, it can be seen that the relative intensity of the various orders appears to shift upon the application of tension, the lower orders becoming more intense. In Figure 25 is shown a diagrammatic representation of the extent to which the intensity of each order was found to vary in each of the three cases. The intensity value of each interference is a purely arbitrary one taken from the microdensitometer reading and, therefore, is only relative.

Concerning the Nature of the Structural Unit Indicated by the Long Meridianal Spacing.—Two explanations can be given for the appearance of this long meridianal spacing. The first is that the protein is made up in such a manner that some particular amino acid having an extraordinarily great scattering power is periodically repeated along the chains but without any regular discontinuity in the covalent peptide bonds. The second is that the protein consists of large molecules or crystallites of a very definite length whose ends are regularly arranged in planes along the fiber axis. From the shortening effect upon the long spacing produced by chromicizing, either theory may be correct. In this process, a slight crumpling of the chains which apparently takes place, would result in a shortening of the "d" value of this plane. From the simultaneous great contraction in length of a fiber and the complete destruction of the long spacing by the action of concentrated acids, alkalies and salts and hot water, the second possible explanation seems to be much more logical. The x-ray pattern shows very long molecules or crystallites to remain after such treatment and that they may be easily oriented, but no longer is the regular periodicity along the fiber axis noted. It is difficult to see how treatment merely with a concentrated salt solution such as $CaCl_2$ at room temperature might disrupt a covalent bond along a protein chain.

Evidently there is some sort of an attraction, probably secondary valence forces, or a powerful cementing material between the ends of the micelles in collagen. This is apparent, first, from its high tensile strength as compared to that of gelatin, and second, from the fact that although a sodium hydroxide addition compound of gelatin can easily be prepared, it cannot be made to give a well-oriented diffraction pattern. This is probably because in gelatin, the attractive forces between the ends of the micelles have been destroyed and the tension upon the ends of the molecules, so necessary for pulling the units in a definite geometric configuration, can no longer be exerted by applying tension at the ends of the protein fiber as a whole. Although not conclusive, the evidence seems to indicate strongly that this very long repeating unit is due to a definite discontinuity of the peptide bond.

A reasonable explanation of the phenomena underlying the shift in relative intensity of the different orders of the long spacing upon drying a swollen fiber under tension cannot yet be given.

STUDY OF THE DIFFRACTION INTERFERENCES PRODUCED BY RADIALLY ORIENTED, NATURALLY OCCURRING WAX MOLECULES ON INTESTINAL WALL COLLAGEN FIBERS

The collagenous submucous layer of the intestinal wall of animals, particularly the sheep, possesses certain peculiar properties which make it well suited for raw material in the manufacture of surgical sutures and ligatures, musical instrument strings, tennis racket gut, etc. A microscopic examination of a sheet of collagen from this source reveals its structure to be made up of tiny interwoven fibers which divide and join other fibers in such a manner as to

form a web-like structure analogous to a net. Such an arrangement gives a structure which is easily extended in any direction and has at the same time an enormous tensile strength. Aside from the advantage of being procurable in great lengths, twisted ribbons of intestinal wall collagen possess certain invaluable properties such as pliability, resiliency, etc., which might seem to be connected with the presence of thin films of highly oriented natural wax molecules surrounding the individual fibers.

Early investigators using the x-ray method found collagen from the intestinal wall to be exactly the same as that from other sources, such as tendon. The first evidence for a difference in structure of collagen from different sources was noted in the data published by Clark, Parker, Schaad, and Warren (9) for intestinal wall collagen and that by Wyckoff, Corey, and Biscoe (27) for tendon collagen. As mentioned previously, in the first article is found a reference to a long lateral spacing of 48 Å.U. which was not reported in the work on tendons. Further x-ray analysis has confirmed the presence of this long lateral spacing, *peculiar to collagen of the intestinal wall.* In Figure 14 is shown the interference of this spacing with its first, second, and third orders present.

In the course of preliminary studies of the nature of this interference it was observed that, whereas the interplanar spacing of the 001 plane of collagen varied greatly with the amount of water held by the protein, the value of the longer lateral spacing was not noticeably influenced by swelling. Since these two planes are located in the same zone the swelling data indicated that the two planes could both belong to the same crystal structure only provided they were mutually perpendicular. The results of a study of the position of these two planes with respect to each other is shown in the reproduction of the x-ray patterns. In Figure 14 is shown the diffraction pattern obtained by passing the x-ray beam perpendicular to the fiber axis (long direction of stretched gut) but parallel to the plane of the gut sheets. In Figure 15 the x-ray beam was passed parallel to both the fiber axis and to the plane of the collagen sheet. The interference of the 001 plane in Figure 14 shows the protein fibers to be well oriented. The first three orders of the 48 Å.U. plane are present showing it to be well oriented in the direction of the fiber axis. Figure 15 shows the plane giving the 48 Å.U. interference to be oriented approximately parallel to the flat plane of the sheets, whereas the 001 plane (10.8 Å.U.) is shown to be randomly oriented about the fiber axis. From this it can be seen that these two planes, although in the same zone, are in no respect mutually perpendicular and, therefore, cannot belong to the same crystalline material.

Wax and resins have been reported to be present in surgical catgut to the extent of approximately 1.5 per cent (19). At first this small amount was considered to be insufficient to give a diffraction pattern. Furthermore, samples of raw catgut after extraction with wax and resin solvents, diethyl ether, and chloroform were found to still give the 48 Å.U. spacing. However, it was noted that finished sterile ligatures which had been stored in non-boilable tubing fluid, the chief constituent of which is ethyl alcohol, did not show such a spacing. On the other hand, the spacing was always present in ligatures which had been stored in boilable tubing fluid, the base of which usually is toluene. The supposition that the crystalline material giving this spacing in the spectrum of intestinal wall collagen was of a waxy nature, soluble in hot ethyl alcohol, was easily verified. The x-ray pattern of the collagen sample extracted with hot alcohol showed no evidence of the 48 Å.U. spacing. The residue obtained by evaporation of the solvent consisted of a dark brown waxy material corresponding to about 2.7 per cent by weight of the undried sample. The x-ray pattern of this waxy material is shown in Figure 16. The pattern is characteristic of that shown by most waxes. The first, third, and fifth orders of the 48 Å.U. spacing are shown, which represent the length of the fully extended wax molecule. Other spacings of

4.08, 3.60, and 3.38 Å.U. also are shown, which represent lateral spacings in the molecule. Thus it is shown that the equatorial spacing of 48 Å.U., which previously was thought to be given by intestinal wall collagen, actually is due to the presence of a wax of high molecular weight whose long molecules are highly oriented upon the surface of the protein fibers. In Figure 15, in which the x-ray beam was passed parallel to the flat plane of the collagen ribbons, it can be seen that the major portion of the wax seemed to be located on the surface of the sheets since the plane given by the layers of oriented wax molecules was for the most part approximately parallel to the plane of the sheets. In order to determine whether or not any appreciable quantity of the wax was fixed upon the inner fiber structure of the intestinal wall sheet, a series of partial extractions were made by treating the raw gut ribbons for short periods of time in the hot solvent and the relative rate of disappearance of the circle as compared with the strong arcs of this interference was observed. The patterns obtained from the series of these partially extracted samples of gut showed beyond any doubt that although a large portion of the wax is attached to or near the surface of the gut as a whole, the remainder must be oriented radially upon the surface of the inner fibrillar structure.

Effect of Various Organic Solvents upon the Oriented Wax Films.—The results of extraction experiments on surgical suture samples in which benzene, chloroform, ether, acetone, and petroleum ether were used, showed that, although with each solvent a small per cent of the wax was always dissolved, in no case was the removal so complete after a 24-hour period of hot extraction that diffraction interferences could not be obtained; removal was complete when ethyl alcohol was used.

A rather peculiar result of the solvent treatment upon the effective length of the wax molecules remaining on the fibers was noted. With the high boiling solvents the 48 Å.U. arc usually disappeared completely after extraction and at the same time a new diffuse ring for a spacing of about 33 Å.U. appeared. In the case of the low boiling solvents this change was not found unless the treatment was followed immediately by heating in the oven at 110° C. Drying in the oven to constant weight previous to the solvent treatment was found to aid greatly in this shortening effect. It must be remembered that this shortening takes place only with that portion of the wax remaining, with highly preferred molecular orientation on the fibers. That this phenomenon is only a change in effective length and not the removal or formation of another compound is evident from the fact that upon swelling the fiber in distilled water and drying again, the 33 Å.U. ring disappears completely, while the 48 Å.U. arcs return and are quite as intense as before. In Figure 17 is shown a pattern of a raw catgut suture after extraction with benzene. The presence of both the 48 and the 33 Å.U. spacings shows that only a partial transformation has occurred. Figure 18 shows the pattern obtained after refluxing with petroleum ether followed by heating at 110° C. A complete transformation to the 33 Å.U. length can be seen. In Figure 19 is shown a pattern of a sample treated exactly as described for that in Figure 18 but subsequently swollen in distilled water and dried. The last figure shows a complete reversal to the 48 Å.U. length. The action of the reagents described above upon the oriented film of wax can be explained best by saying that by some peculiar effect of the reagents and heat treatment the long wax molecules are caused to tilt relative to a plane to which they are perpendicular in the 48 Å.U. stage.

Whereas cold ethyl alcohol was found to neither produce the shortening effect nor remove the wax, the hot solution dissolved the wax completely and very rapidly.

Chemical Analysis of Wax.—From a portion of the wax extracted with absolute ethyl alcohol the following results were observed:

(*a*) A few grams treated with 20 per cent NaOH and heated was seen to produce

foaming indicating that saponification had taken place.

(*b*) No sharp melting point was observed. The melting range was found to be from 65° to 80° C., indicating a mixture rather than a single compound.

(*c*) A micro-analysis gave the following results:

Inorganic ash	6.10%
N	1.59%
C	74.44%
H	11.50%
O	remainder

From these data the empirical formula is found to be $C_7H_{13}O$. Assuming it to be an ester in which two atoms of oxygen are necessary, the formula would be $C_{14}H_{26}O_2$, which is that of an unsaturated compound. These data would seem to indicate a combination of two or more of these units to form a rather complex molecule whose effective length is 48 Å.U. However, as is shown below, the effective length of the wax molecule can be made to vary widely depending upon the *p*H of the solutions used in processing of the raw gut.

Influence of Alkalies and Salts upon the Orientation of the Wax Films.—In Figure 20 is shown the x-ray pattern of raw intestinal wall collagen previous to any processing other than scraping and washing in ordinary tap water. No indication of a 48 Å.U. spacing is noted but, instead, there is found an unusually large amount of amorphous scattering near the central spot. A faint concentric ring of about 44 Å.U. is shown, which is due to the presence of mutton tallow and which readily disappears upon extraction with ether. This scattering effect indicates a relatively poor state of orientation of the wax molecules. In Figure 21 is shown the x-ray pattern of the same ether-extracted raw catgut after a treatment with 0.25 N NaOH for a period of twenty-four hours, followed by washing. The pattern clearly reveals the 48 Å.U. spacing characteristic of catgut ligature wax. A subsequent extraction of this material with hot alcohol and evaporation of the solvent also confirmed its identity. From these results it is definitely established that surgical ligature and suture wax is a naturally occurring material of intestinal wall collagen. The x-ray pattern of the ether-extracted material after treatment with a bicarbonate solution, followed by washing, showed only a narrow lateral band of scattering, indicating that the wax molecules were fairly well oriented but lacked something to hold them in well-defined planes, a condition which is necessary to produce a sharp interference. As the first storing medium for the fresh raw gut in the manufacture of surgical ligatures and sutures is usually a strong NaCl solution, a sample of raw gut described above was allowed to soak in such a solution for a period of twenty-four hours. The x-ray pattern of this material showed very distinctly a partially oriented ring of about 42 Å.U., besides the diffuse lateral band described above. A portion of this same sample was given an additional treatment in a strong solution of Na_2CO_3. The x-ray pattern for this sample still gave the 42 Å.U. ring, but the lateral diffuse band seen in the pattern of the samples described above now was resolved into two quite distinct arcs of about 59 Å.U. The pattern is shown in Figure 22. A repetition of this work showed these values to be correct. Moreover, the diffraction pattern of the wax from part of this sample extracted with absolute alcohol revealed these same two spacings with both the first and third orders of each showing. After a further treatment of the same gut sample with 0.2 N NaOH the pattern showed only one interference, the 48 Å.U. spacing common to all samples treated with strong alkali. From the behavior of the effective length of the wax molecules upon treatment with the reagents just described, it seems that the *p*H undoubtedly is a great influencing factor controlling orientation. Films of this wax only a few molecules thick oriented radially on fibrils evidently possess remarkable lubricating properties essential in these fascial tissues. The wax-coated protein also possesses remarkable resistance to enzyme (pepsin, trypsin) digestion.

ABSORPTION EDGES AS AN EXPLANATION FOR SOME PREVIOUSLY REPORTED INTERFERENCES IN COLLAGEN AND GELATIN

In a previous attempt to determine the crystal structure of collagen, Herzog and Jancke (15), using copper radiation, reported an equatorial interference of 23 Å.U., which they assumed to be a lateral dimension of a tetragonal unit cell. This same spacing has since been reported by other investigators (14) but no explanation for it has been given.

In the production of x-rays the spectrum of the characteristic radiation is always superimposed upon that of the general radiation, provided, of course, the potential across the tube is of a certain minimum value, depending upon the metal of which the target is made. For diffraction work when a nearly monochromatic beam is desirable, the tube voltage always is made sufficiently high, such that the intensity of the characteristic radiation is far greater than that of the general. However, it is known that the silver bromide emulsion of the film is not equally sensitive to x-rays of all wave lengths. For a given element rays having a wave length shorter than a certain critical value are absorbed to a much greater extent than rays of a longer wave length. These critical values for Ag and Br are 1.379 and 0.918 Å.U., respectively. Thus for a given plane, providing its scattering power is high and the general radiation is not filtered out, there are registered upon the photographic plate, additional interferences corresponding to the wave lengths to which the emulsion is most sensitive. The diffraction angles for these interferences are, therefore, independent of the metal of the target and depend only upon the value of the interplanar spacing. Such interferences are commonly seen in patterns of inorganic crystals which show strong planes and are usually called "absorption edges."

To investigate the nature of the spacings reported in collagen, the unfiltered beam was passed parallel to the fiber axis of a bundle of rat tail tendons, 2 mm. in length. By this method the reflection from the 001 planes is very intense and conditions are ideal for showing the absorption discontinuities. In Figure 23 is shown the pattern obtained with copper radiation, and in Figure 24 is shown a pattern of the same sample using iron radiation. The two patterns are quite similar considering the difference in wave length of the Kα used in each case. However, a distinct inner ring can be seen which is of exactly the same diameter in both cases. By measuring the outermost edge (the true absorption edge) and taking the wave length of 0.918 Å.U., the Br absorption edge value, these rings were found to be critical absorption bands of the 001 plane. In the pattern given by copper, if the diameter is measured from the most intense portion of the ring and the wave length is erroneously assumed to be the Kα of copper, the value of 23.4 Å.U. is obtained. This value is found to check exactly with that reported in the above reference and, therefore, there is little doubt but that the interferences listed by the authors mentioned were due to the same phenomenon. A similar explanation recently has been made to account for some anomalous lines present in the spectrum of cellulose and its derivatives (23).

SUMMARY

1. The x-ray diffraction patterns of unmodified collagen and gelatin are discussed. It is pointed out that no entirely satisfactory interpretation of the crystal structure can be made from the diffraction patterns of these materials.

2. The preparation of addition compounds of collagen with sodium, potassium, and lithium hydroxide is described. The crystal structure of the sodium hydroxide-collagen compound is determined. The structure is found to belong to the orthorhombic system with the following unit cell dimensions: a = 5.32 Å.U.; b (fiber axis) = 6.50 Å.U.; c = 11.90 Å.U. The unit cell contains two amino acid residues. The alkali-amino acid ratio is found to be approximately 1:1. The structures of the potassium and lithium compounds are

found to be different and a tentative solution is given for the potassium compound.

3. Different methods in technic in the study of very long interplanar spacings are given. A periodicity of 432 Å.U. along the fiber axis of collagen is measured directly from diffraction interferences. The effects of chromicizing, hot water, concentrated acids, alkalies, and salt solutions and drying under tension upon the long meridianal spacing in collagen are discussed and certain indications concerning the nature of the large structural unit shown by this spacing are mentioned.

4. The presence in intestinal wall collagen of naturally occurring wax molecules oriented radially upon the surface of the collagen fibers is shown to produce a lateral 48 Å.U. interplanar spacing previously thought to be given by the collagen crystallite itself. Studies of peculiar orientation effects of solvent treatment, alkalies, and salt solutions upon the oriented wax molecules are described.

5. Some previously reported interferences in the x-ray spectra of unmodified collagen and gelatin are shown to be due to bromine absorption edges from the 001 plane.

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TYPHOID SPINE[1]

By MAJOR ALBERT BOWEN, M.C., *and* CHARLES L. McGEHEE, FIRST LT., M.R.C.,
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TYPHOID fever ceased to be a common disease about the time that roentgenographic apparatus came widely into use, and while it is still present in some rural regions, it has become almost a rarity in city hospitals. Hospitalization of the C.C.C. has brought a number of cases into the Fort Sam Houston Station Hospital from rural camps.

The text-books list "typhoid spine" among the complications, but few of the present generation of physicians have seen this clinically, and there is no reference to this condition in the roentgenologic journals of the last ten years. The following case may be of interest as exhibiting rather typical typhoid spondylitis.

The patient, a civilian, son of a soldier, aged 15 years, was admitted to the Station Hospital on Aug. 5, 1935. He had been visiting in the country in July. On August 10, a diagnosis of typhoid fever was confirmed by a positive blood culture. The patient was quite ill and it was thought that he would die. However, he responded to the instituted management, and on September 11, culture of feces was negative for *Bacillus typhosus*. His convalescence was slow. On October 13, he was permitted up in a wheel chair with apparently no ill effects. On October 15, he was permitted to take a few steps, at which time there were no complaints. On October 27, he began to complain of pain in the lumbar region of his spine. On examination, the patient presented a peculiar posture on standing. There was a scoliosis of the upper dorsal vertebræ; the lower dorsal and lumbar vertebræ were rigid. Viewed laterally, he presented a sway-back appearance; he could not bend forward and

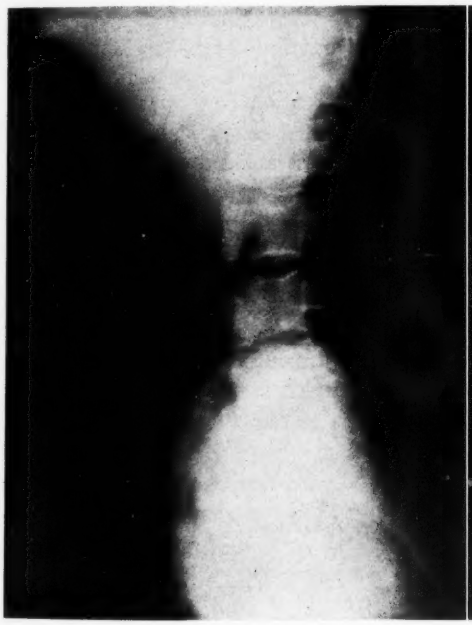

Fig. 1.

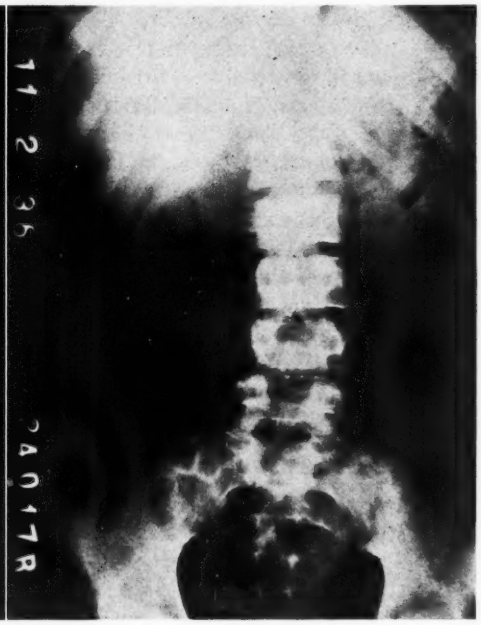

Fig. 2.

[1] Published with the consent of the Surgeon General of the Army, who assumes no responsibility for any statements contained herein.

the spinous processes of the lumbar and lower dorsal vertebræ were tender on pressure. A roentgenologic examination of the pelvis, lumbar, and dorsal vertebræ was requested. The report follows.

Nov. 2, 1935: "The thoracic spine shows some scoliosis toward the right. No destructive lesions are seen; the intervertebral spaces appear normal. The lumbar spine shows a rather marked scoliosis toward the left. The bodies of the first three lumbar vertebræ are fairly normal, but there is some irregularity of the joint surfaces. There is some irregular absorption of the anterior portion of the body of the third lumbar. The bodies of the fourth and fifth show destructive changes, the joint space being practically obliterated and markedly irregular. The lower border of the fifth appears to be intact. There is considerable decalcification of the sacrum with outlines barely visible. No joint line is seen at the sacro-iliac articulations, and there appear to be destructive changes in the sacro-iliac joints.

"*Impression.*—Typhoid spondylitis of the lumbar spine and sacrum."

Dec. 2, 1935: "There is apparently further destruction of the bodies of the fourth and fifth lumbar vertebræ. There is a long spur on the lower right border of the fourth lumbar. The bone structures in the sacrum appear more normal and better calcified, and the outlines are a little clearer."

Clinically, the patient is in a plaster shell and is quite comfortable.

A type of infectious spondylitis due to inflammatory changes in the ligaments and bones of the spine, occurring during an attack of, or convalescence from, typhoid fever was first described by Gibney as the "typhoid spine." The lumbar region is most frequently affected. According to the literature, the symptoms are paroxysmal attacks of intense pain with muscular spasm associated with tenderness. In some cases the nerve roots are involved, with sensory and motor disturbances. Spondylitis is more common in males. It may recur after apparent recovery, but permanent deformity rarely follows. Suppuration has not been observed.

Holmes and Ruggles (1) state: "Typhoid spine appears in the form of localized areas of rarefaction near the corners of vertebral bodies, with local thinning of the adjacent disc and the subsequent development of a heavy bony bridge about the focus and disc."

The treatment consists in immobilization of the spine on a Bradford frame or in a plaster cast during the acute stage, which should be followed by a brace commensurate with the affected region until all symptoms have subsided, which usually requires from six months to one year. Cure is effected through proliferative changes which result in the formation of osteophytes and produce ankylosis.

REFERENCE

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THE SIGNIFICANCE OF X-RAY CONTROL IN ARTIFICIAL FIXATION OF THE MEDIASTINUM SUPPLEMENTING CLOSED INTRAPLEURAL PNEUMONOLYSIS IN CAVERNOUS PULMONARY TUBERCULOSIS[1]

By FELIX BAUM, M.D., *Newark, N. J.*

AN artificial pneumothorax can be considered effective only if an anatomical closure of the tuberculous cavity can be proven radiographically. The clinician who, after pneumothorax treatment, is inclined to rely mainly on the improved clinical picture, gain of weight, disappearance of toxic symptoms and of tubercle bacilli, and who, therefore, considers the collapse as clinically effective, will often be disappointed to learn from the radiologist that in spite of an apparent clinical improvement the tuberculous cavity is still open and that his problem is far from being solved.

In intrapleural pneumonolysis, for instance, it happens very frequently that a tuberculous cavity does not close in spite of a successful severance of pleural adhesions by the Jacobaeus method. The reason for such failures is mostly a stiffened wall of the cavity. Surgeons like Sauerbruch, therefore, often hesitate to try this method and prefer more radical procedures, such as thoracoplasty.

We have learned from Potter,[2] who has probably treated the largest number of such cases, that artificial fixation of the mediastinum is an excellent aid in rendering an unsatisfactory pneumothorax effective. One allows the mediastinum, which, in the majority of such cases, is pushed over to the opposite side, to return to its normal position under fluoroscopic control and injects from 10 to 15 c.c. of sterile, chemically pure mineral oil into the pleural sac. In this manner one produces an artificial pleural effusion with a temperature of 102.8 to 104° F. lasting for a few days. During the following eight weeks, one fluoroscopes the patient at short intervals in order to determine whether or not the mediastinum is movable during respiration. Omission of fluoroscopy leads invariably to failures. As soon as the radiologist can prove complete fixation of the mediastinum in the mid-line, the fluid is aspirated and artificial pneumothorax continued. The tuberculous cavity closes in a great number of cases and the problem is solved. The same supplementary procedure is necessary in cases following closed intrapleural pneumonolysis, in which the cavity seems to be incollapsible for reasons mentioned above. The following case is an interesting proof.

A girl, aged 16 years, showed, on admission to the Deborah Sanatorium, Browns Mills, N. J., a cavernous tuberculosis of the right upper lobe with pericavernous infiltration (Fig. 1). Artificial pneumothorax was attempted for three months but the cavity failed to close in spite of high pressure insufflations, because of a pleural adhesion which held the cavity open (Figs. 2 and 3). The patient was, therefore, sent to me for electrosurgical severance of the adhesion. In spite of the fact that the operation was successful, the cavity failed to close after numerous artificial pneumothoraces (Fig. 4). The only change that the roentgenologist could report was a mediastinal herniation (Fig. 5). In spite of clinical improvement, it was decided to follow Potter's suggestions to aspirate air, under fluoroscopic control, and to allow the mediastinum to return to its original position. A mediastinal fixation

[1] X-ray Demonstration, Clinical Meeting, St. Mary's Hospital, Orange, N. J., April 14, 1936.

[2] B. P. Potter. Preliminary Report, Aerztliche Sammelblaetter, Jan. 25, 1935. Final report in print.

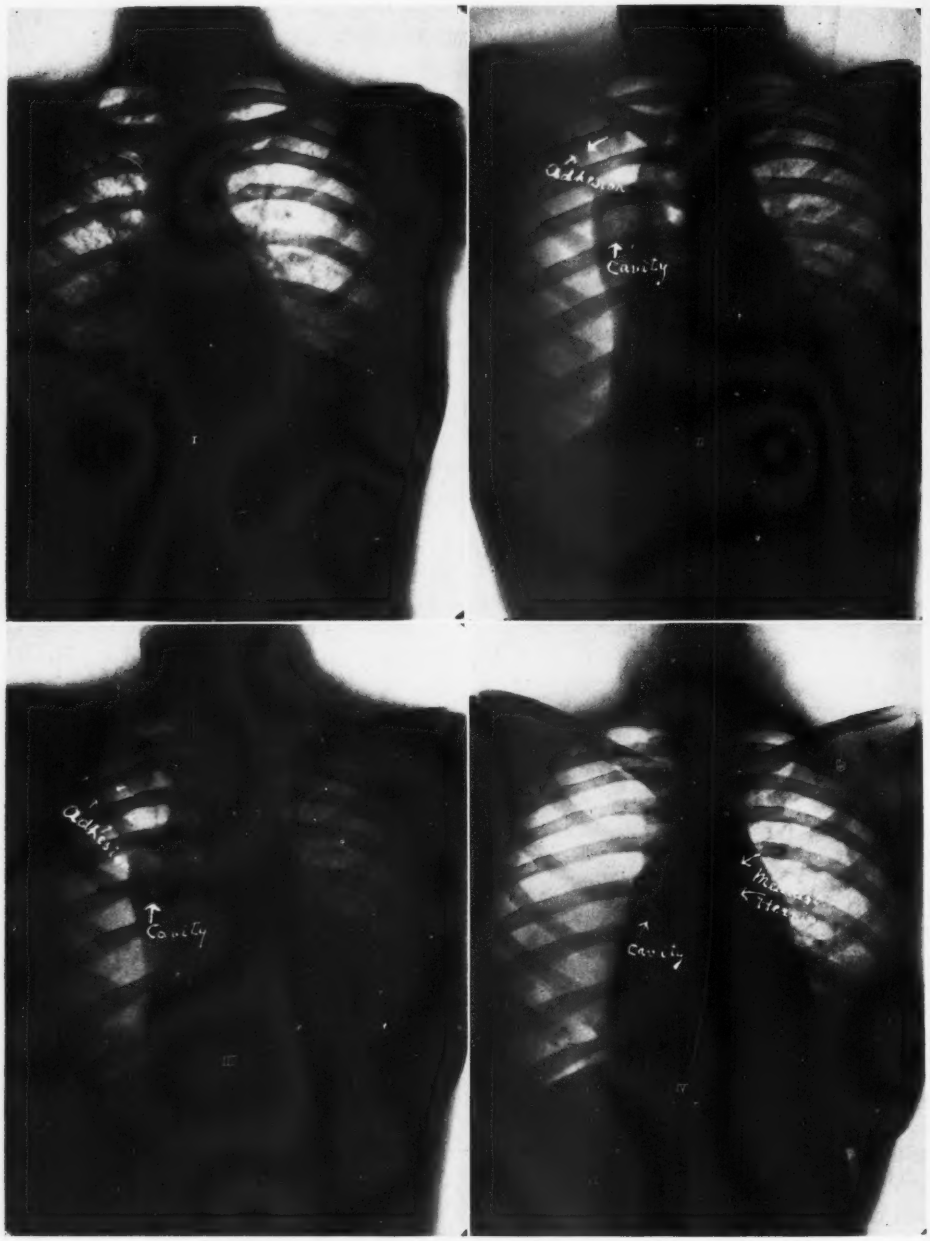

Fig. 1 (*upper left*). Tuberculous cavity in the right upper lobe—pericavernous infiltration.
Fig. 2 (*upper right*). Pneumothorax ineffective on account of adhesions.
Fig. 3 (*lower left*). Pneumothorax still ineffective—increased intrapleural pressure.
Fig. 4 (*lower right*). Adhesions severed electrosurgically. Cavity is still open. Mediastinum has shifted to the left. Mediastinal hernia.

in the mid-line was then produced by artificial pleural effusion (described above) and, after aspiration of fluid, the pneumothorax was continued with small amounts

Fig. 5.

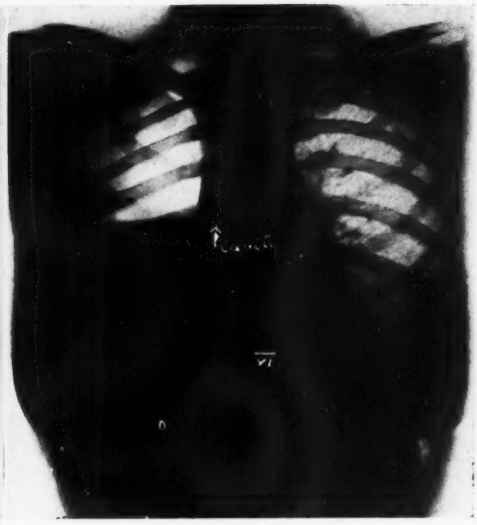

Fig. 6.

Fig. 5. Cavity is still open. There is increased intrapleural pressure. The mediastinal hernia is larger.
Fig. 6. Mediastinum allowed to return to mid-line. Artificial fixation of the mediastinum by artificial fluid formation. Cavity is still open.

of air given at short intervals under negative pressure (Fig. 6). The attempt was successful (Fig. 7). It shows a complete anatomical closure of the cavity. The sputum has remained negative ever since. Artificial pneumothorax is being continued.

SUMMARY

The importance of x-ray control in cases of ineffective collapse following closed intrapleural pneumonolysis is shown. A case is presented in which, after pneumonolysis, the collapse seemed to be clinically effective but proved to be anatomically ineffective as demonstrated on the x-ray film. The anatomical closure was possible only after a supplementary artificial fixation of the mediastinum under x-ray control.

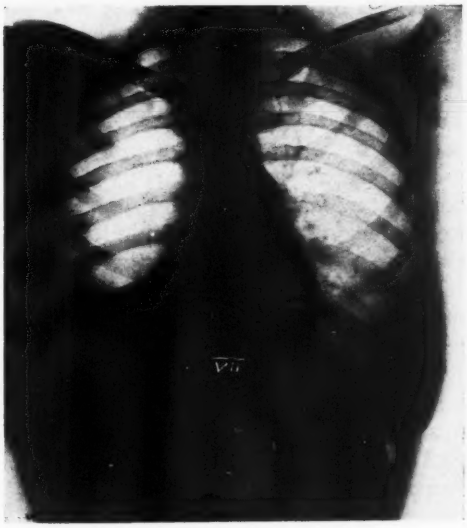

Fig. 7. Fluid aspirated, pneumothorax continued. Anatomical closure of cavity.

765 South 10th St.

AN IMPROVED METHOD FOR MAKING REPRODUCTIONS FROM X-RAY FILMS

By BERNARD H. NICHOLS, M.D., *and* J. C. ROOT, M.D., Cleveland Clinic, *Cleveland, Ohio*

THE making of positive reproductions from x-ray films by the methods now in general use is a tedious and time-consuming task. We have sought to simplify and improve this type of work, as well as to reduce the cost in cases in which a large number of copies must be made. In addition, the method to be described provides for another means of lantern slide projection, namely, the film positive printed on a single strip of film.

The method that we have found most acceptable for this work is based on the miniature camera using 35 mm. motion picture film. This film has the advantage of being very fine-grained; many negatives can be stored in a comparatively small space, and the cost per negative, when the film is purchased in bulk, is about one cent. The equipment consists of a Leica model F camera with an f 3.5, 5 cm. lens, a sliding focusing copy attachment with an arm for attaching to an upright, and an illuminating box. While any available view box may be used, we feel that there are distinct advantages in the illuminator which we have designed and are now using.

The illuminator is made up of a metal box 18 1/2 inches long, 16 1/2 inches wide, and 19 inches high with welded seams. On the floor of this is a base board upon which are 12 sockets for electric lights, which are arranged in three rows of four each. The light source consists of twelve 40-watt lamps. A sheet of opal glass is placed 10 inches above the base board for primary diffusion of the light. Between this sheet of glass and the bottom of the box, vents are cut in the sides to eliminate the heat given off by the lamps. A piece of plate glass, frosted on one side, is enclosed with metal strips to form a tray. When assembled this is inserted in grooves 5 3/4 inches above the opal diffusing glass and will hereafter be termed the "sand tray." The top of the box, on which the films are placed, consists of a second piece of opal glass 2 1/2 inches above the sand tray. Hinged to the back of the box is a heavy

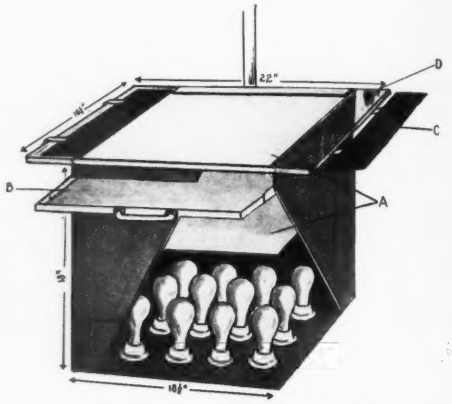

Fig. 1. Diagram of illuminating box. (*A*) Opal glass; (*B*) Sand tray; (*C*) Mask; (*D*) Plate glass.

sheet of plate glass which serves to hold the film flat and in good contact with the opal glass top. The construction of the illuminating box is shown in the diagram (Fig. 1). The metal upright, made from 1 1/4 inch tubing, is fastened to the rear of the box. For convenience, small grooves are cut in the tubing to designate the film-camera distance for the different sized films.

For operation, the apparatus is set up as shown in Figure 2. Masks may be made from black fiber cardboard to cut out any undesirable illumination coming from around the sides of the smaller films. For films of average density and light distribution, the sand tray, consisting of the frosted plate glass, may be left *in situ* and serves to further diffuse the light coming through it. If any particular portion of the film needs accentuation, this may be accomplished by means of the sand tray. In this case the tray is removed from its position and set, with the film in place, on top of the plate glass pressure plate. Fine sand from a con-

tainer is then sifted over the areas in which the intensity of the light is to be diminished. For this purpose an ordinary tin can with a fine mesh wire screen bottom may be used. The sanding procedure may be facilitated if different sized openings are available for the bottom of the dispenser. With these the sand may be better placed over small or irregular areas. After the proper amount of sand has been distributed over the surface, the tray is returned to its position below the top opal glass. In using the sand tray, the frosted side of the glass should be uppermost so that the sand will not be so apt to shift about.

The question may arise as to whether or not the sand might not cause unsightly edges or lines in the resulting negative. Since the camera is comparatively close to the object, the depth of focus is necessarily shallow, and it will be found that the distance, 2 $^1/_2$ inches below the film, is ample to produce a blending or softening of the sanded areas. The depth of focus may, of course, be further shortened by using the lens with the diaphragm at a large aperture.

Many films are available in the 35 mm. size; in fact, more than in any other width, which is another advantage in favor of the miniature camera, as it permits of a careful choice. In selecting a film for this specialized type of work it is absolutely essential that it be of the fine grain type since large prints or projections may be required from the negative. Speed is not a factor; hence it is better to choose a slow film since it is a well-known fact that the slower films are also the finest grained. We have found the Eastman Background Negative to be very well fitted for our purpose since it meets the stated requirements. It is of the fine grain type and has a slow emulsion, the Weston rating being twelve by daylight and eight by artificial illumination. This film is not to be confused with the Panatomic, which has a similar but faster emulsion.

Using the above factors to rate the film speed, the exposures may be made with the aid of a Weston meter if there is any doubt as to the correct aperture or the amount of time to use. Care must be exercised, however, to obtain the meter reading for the part of the film that is of the most importance. The proper exposure, for an average chest film as an example, will be one second at an aperture of f 11. With a little experience, the exposure factors may be estimated and, to speed up the work, one may dispense with the meter.

Fig. 2. Apparatus as set up for use.

Processing the film is a simple procedure, and it will be found that perfect results may be obtained if ordinary care is used. It is, of course, as important to use a fine grain developer as it is to use a fine grain film. Here, too, there are many choices as there is an infinite number of different kinds of developers. However, since our primary object is to use the simplest methods consistent with good results, we must look for an easily prepared solution with a short

developing time. Such a preparation is the Eastman Ultra-fine Grain Developer which may be procured already mixed, in a dry form, so that it is only necessary to add water. This, we believe, will give as fine a grain as paraphenylenediamine, and requires only a fourth of the time needed for the latter. Development by time and temperature is the most satisfactory method, and properly exposed films will yield good negatives if developed for $8^1/_2$ minutes at a temperature of 65° F. The fixing and washing is carried out as with any other type of film. It may be desirable, however, to use an additional hardening bath to prevent scratches and other markings that might come from handling or rubbing of the surfaces together with dust in between.

COMMENT AND SUMMARY

A simplified process for the reproduction of x-ray films has been described. Less time is consumed in making the exposures than in the methods now in general use since it is only necessary to wind the film and there are no film holders to load and change for each exposure. The cost per negative is low and will be about one cent if the film is purchased in bulk.

Another advantage to bulk film is the fact that as much film as needed, from a few to 36 exposures, can be loaded in the magazine as is desired. The advantage of developing 36 exposures on a single strip of film can readily be seen when one considers the work required to process an equal number of cut films or plates. The problem of storage is a minor consideration but is nevertheless a point to bear in mind if a large number of copies is to be made.

The negatives, after they have been processed and dried, may be used in a number of ways. For projection, excellent results may be had by using the 35 mm. projector, the negatives of which may be used without further printing, or positives may be made either on 50 mm. slides or on a positive film strip (1). The latter method of showing reproductions is very convenient if travelling, as the weight of the projector and 100 or 200 pictures will be less than that of 50 standard lantern slides. Other uses are in the making of standard lantern slides, prints, or transparencies. These are, of course, all made by enlarging so that they may be of practically any size desired.

The present trend in reproduction seems to be toward the use of positive pictures so that the copy has the same characteristics as the original film. Hence, it is felt that the simplified and inexpensive method of securing such reproductions which are presented here may be of value to others confronted with the problem of producing satisfactory positive reproductions.

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(1) Root, J. C.: Film-slide Positives on 35 mm Film. The Camera, April, 1935, **50**, 238–241.

CASE REPORTS

HYPERPARATHYROIDISM

CASE REPORT

By E. T. WENTWORTH, A.B., M.D., F.A.C.S., *and* L. R. LINGEMAN, B.S., M.D., *Rochester, N. Y.*

From the Division of Orthopedic Surgery and Department of Radiology, Rochester General Hospital

The patient, Mrs. A. C., No. 75,021, white, female, aged 33 years, was admitted to the Rochester General Hospital on July 25, 1932. She complained of pain in the feet, legs, and back, causing difficulty in walking and constant fatigue. She had been first seen on July 22, 1932, because of the above complaints. The finding of a tumor in the right side of the neck and marked osteoporosis of the spine and pelvis, as revealed by an x-ray examination, led to a tentative diagnosis of hyperparathyroidism and she was referred to the hospital for further study.

The past history was unimportant.

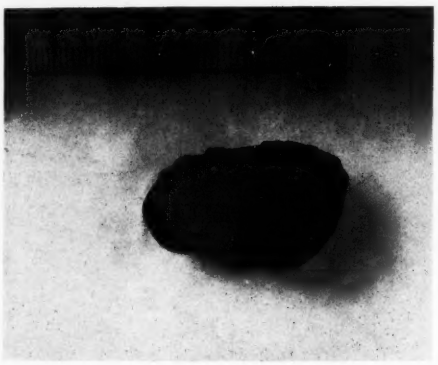


Fig. 1. Gross appearance of the parathyroid tumor.

The present illness began about eighteen months before admission. She had been forced to give up her work in a tailor shop because of the pain in her feet, legs, and back. The pain in her extremities seemed to be affected by changes of weather and she was treated for about six months for rheumatism without relief. She had one seyere attack of colicky pain in the right upper quadrant in 1931, diagnosed as "gallstone colic." She also gave a history of two falls within the year previous to her admission, apparently unrelated to her present complaints. There had been some constipation and nocturia.

Physical examination reveals a fairly well nourished Italian female who appears to be in

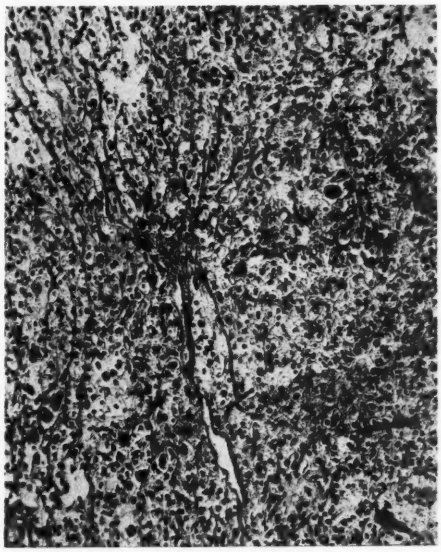


Fig. 2. Photomicrograph of the parathyroid tumor presenting similarities to the structure of hypernephroma.

pain on all motion of the back and lower extremities. There is a small nodule below the right pole of the thyroid. The thoracic cage shows marked deformity, there being a deep depression running parallel to the sternum at the costocondral junction. The lower extremities seem atrophic, particularly the left. There is pain on pressure over the ribs, spine, and pelvis.

Orthopedic Examination.—The patient walks with a very waddling hip gait and stands with marked dorsal kyphosis. Both feet are flat and tender. There is scarcely any lumbar motion in any direction. The pain is not localized, but is present all around the lower back. Lower extremity motions are all carried out with much effort and considerable complaint. There are definite sacro-iliac findings. There is marked atrophy of the gluteals and muscles of the lower extremities.

Films of the chest show marked deformity of the ribs anteriorly and laterally. Examination of the spine and pelvis shows marked osteoporosis. The density of the bones of the upper extremities appears to be almost normal. A film of the femur shows marked osteoporosis.

LABORATORY EXAMINATION OF THE BLOOD

July 22, 1932	Calcium—14.8
	Phosphorus— 2.2
Aug. 6, 1932	Calcium—13.8
	Phosphorus— 2.2

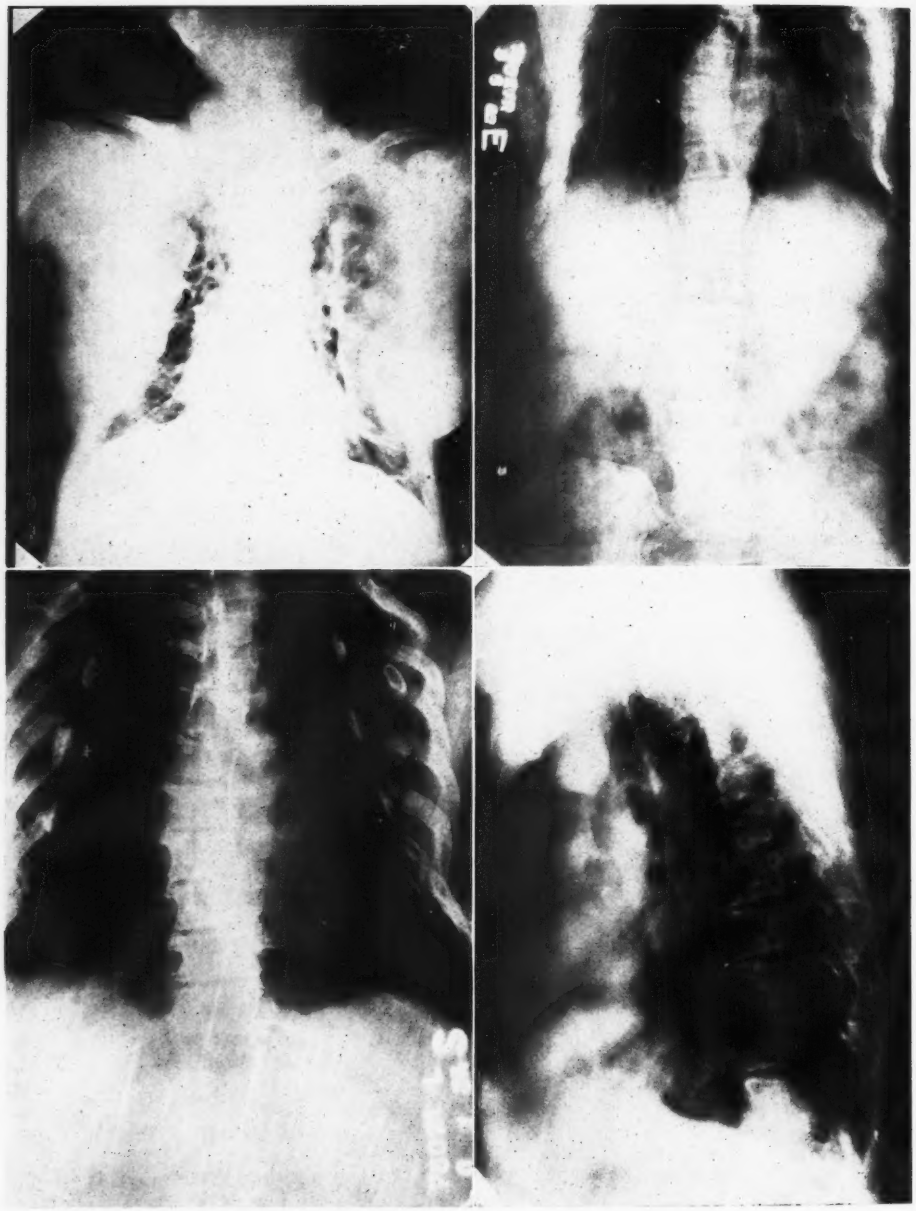


Fig. 3 (*upper left*). Chest film made before operation. This film was one of several made in attempting to get a satisfactory one. Note the deformity at the costochondral junction.

Fig. 4 (*upper right*). This film of the lower thoracic and lumbar spine shows the lack of density and the deformity of the spine and ribs. Compare with Figure 5.

Fig. 5 (*lower left*). This film was made after the operation and return of calcium and phosphorus to normal levels. Compare with Figure 4.

Fig. 6 (*lower right*). A lateral film of the thoracic spine. Compare with Figure 7, which was made after the operation.

On Aug. 6, 1932, a parathyroid adenoma (Fig. 1) was removed from the right side of the neck.

REPORT OF THE PATHOLOGIST

The specimen is a tumor 32 × 19 × 17 mm. in size, the shape of an olive, which seems to be well encapsulated except for a single area, 1 sq. cm. in size, evidently the place of surgical removal. On cut section, it is found to be formed of compact parenchymatous yellowish-white tissue. No colloid is seen.

Histology.—The tumor is composed of tumor cells which are arranged in broad or thin sheaths (Fig. 2). The nuclei are round and the protoplasm stains light. There is a fairly well-defined cell border. Toward the periphery, the cells become large, with various sized, often giant, nuclei, and a huge protoplasm. These cells are in frequent instances similar to the cells of the adrenal cortex.

Diagnosis.—Parathyroid tumor, possibly malignant.

BLOOD EXAMINATION

On Aug. 8, 1932, forty-eight hours after operation, it showed the following:

Aug. 8, 1932 (48 hours after operation)	Calcium—10.4 Phosphorus— 1.8
Aug. 9, 1932	Calcium— 8.2
Aug. 10, 1932	Calcium— 8.2 Phosphorus— 3.4
Aug. 12, 1932	Calcium— 7.5 Phosphorus— 8.4
Aug. 16, 1932	Calcium— 7.4 Phosphorus— 5.0
Sept. 7, 1932	Calcium—10.4
May 21, 1933	Calcium—11.7

(?) (Quantity not sufficient.)

The patient developed a psychosis the day following her operation. She became excited, irrational, and had delusions. This condition cleared in about one week.

She was discharged to the Out-patient Clinic on Sept. 9, 1932. Since her discharge, she has shown continuous improvement in her condition. She was last seen on May 28, 1934, at which time she was not only symptom-free, but her blood calcium and phosphorus were normal. An x-ray film of her bones showed about normal density.

CONCLUSIONS

We have reported a typical case of hyperparathyroidism, due to a parathyroid adenoma. The interesting features are: The deformity of the thoracic cage, due to atmospheric, pressure, and muscle pull on the softened ribs; pains in the back and lower extremities with atrophy of muscles; general weakness and constantly maintained fatigue posture; generalized tenderness over the bones; a history of constipation and polyuria; the fortunate location of the parathyroid adenoma; the prompt fall in the blood calcium; the post-operative psychosis, and, finally, the complete clearing of symptoms following the removal of a parathyroid adenoma.

Fig. 7. Compare with Figure 6. Note the increased bone density and the deformity of the lateral aspects of the ribs.

We are indebted to Dr. Istvan Gaspar for the description of this tumor and for the laboratory work.

THE TREATMENT OF RHINOSCLEROMA WITH ROENTGEN RAYS

By GUSTAV PETER, M.D., *Mexico City*

Translated from the German by E. T. LEDDY, M.D., Mayo Clinic, Rochester, Minn.

One of the most favorable fields in roentgen therapy is the treatment of rhinoscleroma, a lesion which is very common in Central America among the poorer classes and is usually recognized early and treated with good results. However, there are many patients who come to the roentgenologist after their ailments have been mis-diagnosed as syphilis, leprosy, and so forth, having marked deformity, with extensive foul-smelling ulcerations which make

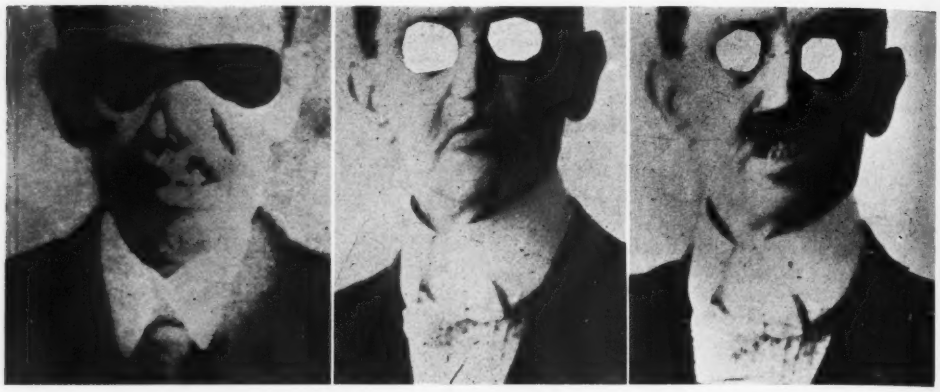


Fig. 1-*A*. Fig. 1-*B*. Fig. 1-*C*.

Fig. 1-*A*. Before treatment.
Figs. 1-*B* and 1-*C*. One-half year after treatment.

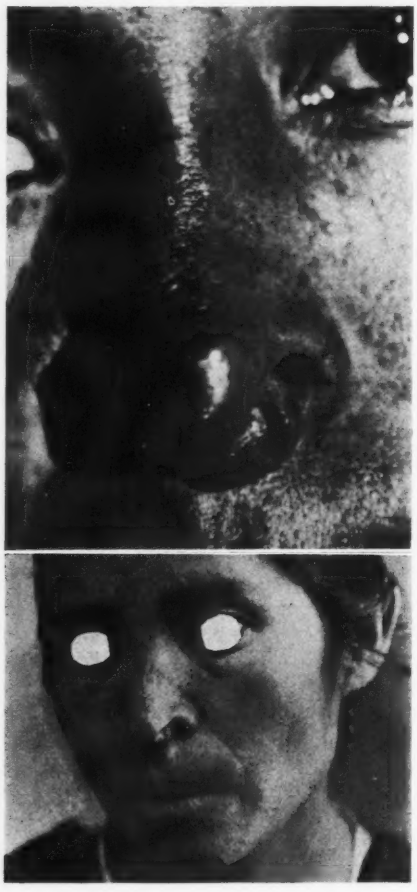


Fig. 2-*A* (*top*). Before treatment.
Fig. 2-*B* (*bottom*). After treatment.

the patient almost a social outcast, or at least limit the likelihood of his employment.

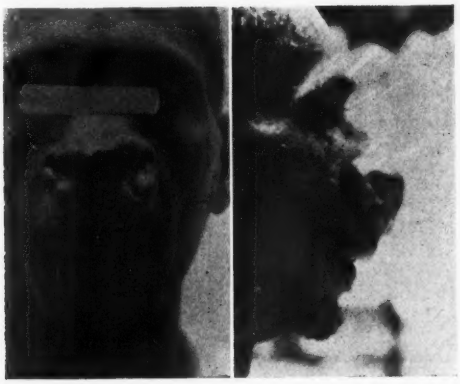
When I first began practice in Mexico City about fifteen years ago I had the opportunity of observing such a patient (Fig. 1-A). At that time there was no mention of this condition in the roentgen literature which was available to me. I, therefore, felt my way along in the attempt to test the sensitivity of this lesion toward x-rays by giving low doses at long intervals, thereby obtaining a surprisingly good result. The objectionable odor of the ulceration had markedly decreased after the first treatment and entirely disappeared shortly after that. The ulcerated areas cleaned up and healed within a few weeks, with the result that there was a disappearance of the ulceration in the nose, lips, and gums (Fig. 1-B). The defect was covered up so completely by a prosthesis with a mustache that no visible trace of the severe disease could be detected (Fig. 1-C). The man returned to work in a short time.

I obtained comparable results in many other cases. Early mild cases were healed in three months, severe ones in about a year. Patients with involvement of the larynx which produced aphonia and difficulty in breathing became symptom-free in from four to eight weeks. The voice returned, and in some patients, who were in danger of losing their eyesight because of involvement of the lachryman canal, the lesions healed up rapidly and completely. Only one patient died shortly after beginning treatment. In spite of the patient's extreme asphyxia we had to begin treatment, and in spite of a low total dose of 600 international roentgens through a small field his dyspnea increased to the extent that tracheotomy was necessary. This produced

Fig. 3-*A*. Fig. 3-*B*. Fig. 3-*C*.

Fig. 3-*A*. Before treatment.
Fig. 3-*B*. During treatment.
Fig. 3-*C*. One year after treatment.

Fig. 4-*A* (*top*). Before treatment.
Fig. 4-*B* (*bottom*). After treatment.



Figs. 5-*A* and 5-*B*. Actually in treatment.

only slight and temporary relief and the patient succumbed shortly after from heart failure secondary to the chronic asphyxia.

Profiting by this experience we always start our larynx cases with low doses given very carefully, often with 20 r. If there is even the slightest reaction which produces swelling, we interrupt treatment for a day, or even a week. In the course of time I have worked out the following technic which best suits the most frequent nasopharyngeal cases and which usually produces prompt healing of the lesion.

After protection of the eyes and cheeks, an anterior field is given over the nose and mouth, and, if it is indicated, lateral fields may be used

in addition. I use a hard radiation of a H.V.L. 1.0 mm. copper, and an intensity of from 5 to 12 r/min., a field of 10/15 cm. with a Holfelder cone, and give daily, or every other day, a dose of from 100 to 150 r measured on the patient's skin with a Mekapion up to a total dose of about 1,000 r, and then after a rest period of from 6 to 10 weeks, usually 8 weeks, I repeat the series two to four times, giving, respectively, 800, 700, 600, 500 and 300 r. Oftentimes, because of the economic condition of the patient, it becomes necessary to modify the basic technic, and this is particularly true of patients who come from a long distance. Case M (Fig. 3) received 3,000 r in 13 months; he received 800 r at the start in the first series, which consisted of two fractions of 250 r and two of 150 r.

Localized lesions in the nose, gums, or pharynx may be taken care of by radium tubes containing from 10 to 50 milligrams. A few days after a single or fractioned dose of 80 mg.-hr., filtered by 0.3 mm. brass or of 250 mg.-hr., filtered by 0.8 mm. brass (corresponding to 300 r of hard beta or 1,200 r of soft gamma radiation), there follows definite regression of the lesion. With the higher dosage there follows a fibrinous mucositis. When this reaction has subsided, further treatment is given if it seems indicated.

If the patient has sufficient time at his disposal, the treatment can be carried through with an almost constant satisfactory result. I have never seen any radioresistance of the tissues even when the treatment was markedly protracted because of the difficulty of the patient's return.

It may well be that the application of still higher dosis in much shorter time by fractionated treatment as outlined by Miescher, Schinz, Borak, and others might produce equally satisfactory results with less difficulty. However, because of the relative benignity of the lesion in question, in contrast to carcinoma to which the method is best adapted, I have not used this technic because of the possibility of some late injury following treatment. With the technic I have described no late damage has appeared up to date.

In later years, there have been many reports in the roentgen literature of results similar to those of mine from other treatment technics.

A critical review of the literature has been given by Martenstein and Jung from Jadassohn's Clinic (Breslau, 1929), in Strahlentherapie, **33**, 220. A Russian work by Kruglikowa, reporting on 172 cases and giving very instructive illustrations, appears in Strahlentherapie, 1934, **50**, 340.

EPILEPSY ASSOCIATED WITH BRAIN CALCIFICATIONS

A CASE REPORT

By EDWARD LEEF, M.D., *San Francisco*

Department of Radiology, Stanford University School of Medicine

There have been several reported cases of calcification in the brain associated with epilepsy and facial nevi. However, these cases are rare, so any new case somewhat similar to these is deserving of report.

The condition has been given several names, among them being Parkes Weber—Dimitri's disease as suggested by Krabbe (1), Parkes Weber (2) having first described the condition in 1922, and Dimitri (3) having presented a case in 1923. However, it was Wissing, in 1921, who first demonstrated the roentgen changes, but the report was not published.

The calcifications are unique in that they appear to be tubular and corkscrew-like and seem to follow the outlines of the gyri of the brain. At first the calcifications were thought to be in blood vessels or in the pia, but the location was not proved until 1934, when Krabbe (1) reported six cases, one of them coming to autopsy. Each of these six cases showed the characteristic calcifications, five in the occipital region and one in the parietal region. The microscopic examination of the material obtained from autopsy showed that there was no calcification in the pia, either in the connective tissue or in the vessels, but that the calcifications were situated in the cerebral cortex, being located for the most part in the second and third layers. The calcifications bore no relationship to the blood vessels.

The reason for the tubular appearance of the calcifications is that the thin layers of calcification are separated from each other by the first layers of the cortex and by the pia mater. The writer has reproduced the x-ray appearance by taking a specimen brain and coating the gyri with silver nitrate, which penetrated a short distance into the cortex. Since the brain was a little dry, the convolutions were separated from each other by a few millimeters and the coating of silver nitrate thus, too, showed a tube-like structure in the film (Fig. 1).

The case here presented (Figs. 2 and 3) shows the changes in the left fronto-parietal region of the brain. The patient, unlike most of the others, shows no facial or cranial nevi. She was referred to the X-ray Department by Dr. Schaller (4), who wished to have studies of the skull because of the patient's long history

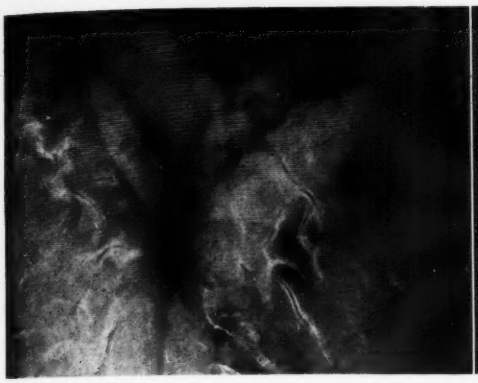


Fig. 1. Specimen brain, showing a reproduction of the tubular densities.

Fig. 2. Shows tube-like calcifications in left parietal region.

of epilepsy. It is through the courtesy of Dr. Schaller that the writer is presenting this case. Dr. Schaller obtained the following history from the mother of the patient.

Miss M. B., aged 17 years, an American schoolgirl; clinical diagnosis, epilepsy. From the age of one or two years the patient suffered from slight epileptic attacks. Recently, however, the attacks have become more severe, occurring at intervals of from seven to ten days, coming on without warning but with loss of consciousness. The attacks are real convulsive seizures, with distortion of the features and accompanied by loud screaming.

The physical examination showed a rather heavy type of child, with a square face, some coldness of the extremities, and slight enlargement of the thyroid. The reflexes, motor system, co-ordination, cranial nerves, and eyegrounds were all negative. No nevi are present.

Examination of the films shows the tubular-shaped corkscrew-like calcifications in the left fronto-parietal region, apparently following the outlines of the gyri of the brain in that region. The pineal gland is so faintly calcified that it can be seen only in the lateral views of the skull. However, in these views the position of the pineal gland does measure three millimeters forward from the forward limit of normal. This forward displacement may be due to atrophy in the region of the calcifications. Studies of the skull using air have not been made.

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(2) WEBER, F. PARKES: Jour. Neurol. and Psychopathol., 1922, **3,** 134; also Proc. Royal Soc. Med., 1928, **22,** 431.
(3) DIMITRI, V.: Rev. Asoc. med. Argent., 1923, **36,** 1029.
(4) SCHALLER, WALTER F.: Personal communication.

Fig. 3. Same case as shown in Figure 2, posterior view.

CONGENITAL BRONCHIECTASIS

By R. VISWANATHAN, B.A., M.D., M.R.C.P. (Lond.), Lecturer in Tuberculosis, *and* P. KESAVASWAMY, L.M. and S., Radiologist, King George Hospital, *Vizagapatam, India*

It is no doubt true, as Reitter[1] says, that comparatively few cases of congenital bronchiectasis as such have been reported in the litera-

[1] REITTER, GEORGE S.: Congenital Bronchiectasis in Children. RADIOLOGY, October, 1935, **25,** 495–497.

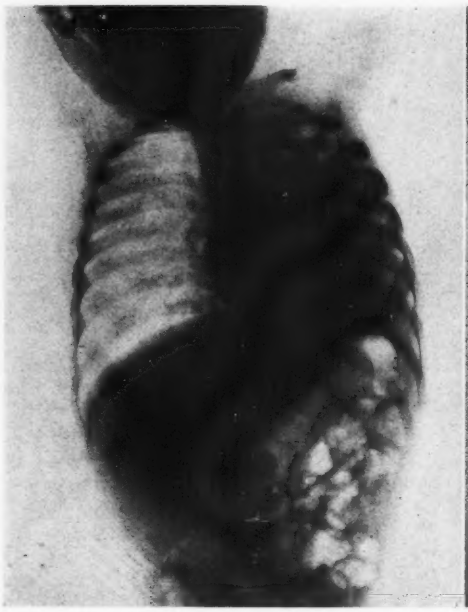

Fig. 1. Congenital bronchiectasis before lipiodol.

Fig. 2. Congenital bronchiectasis after lipiodol.

ture. That is because there is a great divergence of opinion regarding the pathogenesis of bronchiectasis. Many writers still consider that bronchiectasis is in most cases secondary to other pulmonary diseases, but the volume of opinion has gathered during recent years in favor of a congenital origin of bronchiectasis, particularly in children. Lipiodol bronchography has helped considerably in elucidating this vexed problem. By its means, it has been possible to detect a very large number of cases of bronchiectasis during recent years. Besides, it has revealed the existence of a form of bronchiectasis, the so-called dry type, in individuals who are apparently symptomless.

On the basis of (1) the reports of cases of fetal bronchiectasis, (2) the occurrence of bronchiectasis in early childhood without antecedent acute pulmonary infections, and (3) the incidence of the dry type of bronchiectasis in the apparently healthy, one of us (R. V.) put forward the following theory regarding pathogenesis, when speaking before the Andhra medical conference, in June, 1935. The clinical manifestation of bronchiectasis is the result of a pyogenic infection occurring on congenitally dilated or congenitally weak bronchial walls. According to this theory, almost all the cases of bronchiectasis in children are congenital in origin, and the dry type with occasional cough and scanty expectoration is merely a stage in the development of the disease.

The case reported below is particularly interesting because of the peculiar clinical history and the striking radiographic appearances, before and after lipiodol.

S., a Hindu male child, aged one year and three months, was admitted on Jan. 11, 1935, to the King George Hospital, vizagapatam, the complaints being extreme emaciation, slight cough, and infrequent fever. During the first eight months of its life, the patient was said to be perfectly healthy in every way, but since that time he had gradually become emaciated, with a slight gastro-intestinal upset. Two months later he developed a dry cough which disturbed him, especially during the night. Previous to admission the patient had been treated by various doctors, each one having diagnosed the case differently. Thus he was treated for marasmus, tuberculosis, bronchitis, congenital syphilis, avitaminosis, etc.

When the case was brought to the notice of one of us (R. V.), the patient presented the typical picture of a "wizened old man," with sunken eyes, hollow cheeks, wrinkled skin, and practically no subcutaneous fat in any part of the body. Physical examination of the chest revealed marked displacement of the trachea and apex beat to the left, impaired movements, diminished resonance on

percussion throughout the left side, distant bronchial breath sounds, and a few râles. The little sputum and the stomach contents which he vomited occasionally after a fit of coughing, contained no tubercle bacilli.

A radiograph revealed a remarkable appearance. There was a uniform opacity throughout the left side, but with vacuole-like spaces varying from the size of a pea to that of a marble, perceivable through the haziness. Lipiodol injection was done under general anesthesia. A subsequent radiograph showed numerous circumscribed cavities of different shapes distributed throughout the left side.

The above findings are sufficient to warrant a diagnosis of congenital bronchiectasis with atelectasis. Even though the child was apparently healthy for eight months after birth, there is no history of acute pulmonary disease to cause secondary bronchial dilatation. It is, therefore, justifiable to consider that in this case bronchiectasis existed from birth and that the symptoms developed after the eighth month consequent on a chronic bronchial infection.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

WHAT THE FEDERAL HOUSING ADMINISTRATION STANDS READY TO DO FOR RADIOLOGISTS

The radiologist, in order to give the best possible service in his important and responsible work, which may mean the life, health, and well being of many people, should have the best obtainable dependable equipment and machinery. This, however, ordinarily calls for large expenditures of money not always immediately available.

The National Housing Act, through the modernization credit plan of the Federal Housing Administration, offers to responsible radiologists means for obtaining this necessary equipment and machinery on convenient terms extending over a period up to five years.

This modern partial payment plan gives the purchaser the benefit of low prices offered customarily only to cash buyers, and at the same time the advantages of extended credit. Through this plan the buyer may obtain his material immediately and have the benefit of its use while making the required monthly installments.

The prospective user of modernization credit does not apply for funds to the Federal Housing Administration, which lends no money, but to a bank, building and loan association, or other private financial institution insured by the Federal Housing Administration against loss as a result of advances of credit to be used for modernization purposes.

Because of this governmental insurance it is possible to lend larger amounts at a lower rate of interest and for longer periods than would otherwise be possible.

The amount that may be acquired for insured modernization credit will be determined by the credit of the borrower and the location of his work rooms. If the radiologist has his offices in an apartment or office building, hospital or other Class A property, amounts up to $50,000 are available to those of acceptible credit rating for the rehabilitation of properties and the purchase and installation of equipment and machinery necessary in his work.

If, however, his laboratory is located in his home or other private dwelling, he is limited to $2,000, which may be used for structural additions, alterations, and repairs only.

The amendments to the National Housing Act extended the modernization credit provisions of the Federal Housing Administration one year to April 1, 1937. They provided, also, that the borrower must be the owner of the property to be modernized or must have a lease on it extending six months beyond the period of the loan. Purchase and installation of portable machinery or equipment as well as new construction on vacant property are ineligible.

Loans of $2,000 or less are eligible for insurance only if the proceeds are to be used to finance structural repairs, alterations, or additions upon existing buildings. Borrowers up to $2,000 may use it for such purposes as painting, decorating, the installation of modern heating, plumbing, wiring, and similar systems.

On Class A properties the above improvements may be made with loans up to a maximum of $50,000, and, in addition, certain equipment and machinery may be purchased and installed, provided the amount borrowed for this specific purpose exceeds $2,000.

The responsible applicant for modernization credit under the Federal Housing program will find that obtaining funds from an approved lending agency is a simple procedure. He will present a credit statement and an estimate of work to be done, and if acceptible to the private financial institution, the necessary amounts will be forthcoming without undue delay.

The amount of credit and time allowance, interest and service charges will be the subject of mutual agreement between the borrower and lender.

The lending agency is usually qualified to pass upon eligible equipment, but in case of doubt, correspondence with the national headquarters of the Federal Housing Administration in Washington will result in specific rulings if a complete description of the article desired, accompanied by a photograph or other picture, is sent.

The radiologist may be particularly interested in acquiring radiothermy apparatus (non-portable); ultra-violet apparatus (non-portable); x-ray generators; x-ray tables; x-ray units (non-portable); diathermy apparatus; multiple wave generators; short wave diathermy units, etc., and will find that the use of the Federal Housing program offers him unusual advantages in the way of terms and credit.

The following classifications of equipment are, subject to the general principles of eligibility as stated, eligible for professional and office use:

Anesthesia machines (installed)
Autoclaves
Artificial fever apparatus (installed)
Centrifuges (installed)
Deep therapy tube stands
Dental equipment (installed)
Diagnostic machines (non-portable)
Electrocardiographs (installed)
Foot manipulation machines, installed types
Hemoglobinometers
Hydrotherapy apparatus (installed)
Infra-red lamps—professional (non-portable types)
Lighting systems—emergency
Mercury lamps (non-portable)
Operating tables
Optometric equipment
Oxygen tents (non-portable, hospital types)
Resuscitators and inhalators (non-portable)
Solar arc lamps (non-portable)
Sterilizers (electric or gas)
Suction and pressure units
Transformers (current)
Vapor baths, cabinet types (installed)
Fluoroscopes, horizontal and vertical (installed)

ANNOUNCEMENT

POSTPONEMENT NOTICE

The First International Conference on Fever Therapy, originally scheduled for the end of September, 1936, has been postponed because of numerous requests, to permit more time for the preparation of material. The new dates set for this Conference are March 30 to April 2, 1937. The sessions will be held at the College of Physicians and Surgeons, Columbia University, New York City.

The advances in the treatment of gonorrhea, syphilis, and other diseases by pyretotherapy are of great social significance. Invitations on behalf of the Conference will be issued by the State Department of the United States to Ministries of Public Health of other countries. The Medical Departments of the Army, the Navy, and the Public Health Service of the U. S. A. will be represented, as will also the New York City Departments of Health and of Hospitals.

A tour has been arranged to take place immediately following the Conference, to enable physicians to observe the technics employed in fever therapy in some of the hospitals in the eastern section of the United States. Among the institutions to be visited are the Strong Memorial Hospital of the University of Rochester, N. Y.; the Henry Ford Hospital, Detroit, Mich.; the Mayo Clinic, Rochester, Minn.; the Kettering Institute for Medical Research at the Miami Valley Hospital, Dayton, Ohio; Northwestern University Medical School, Chicago.

Further information regarding the Conference may be obtained from the General Secretary, Dr. William Bierman, 471 Park Ave., New York City, U. S. A.

COMMUNICATIONS

THE ILLINOIS RADIOLOGICAL SOCIETY

The quarterly meeting of the Illinois Radiological Society was held in Bloomington, at the Hotel Rogers, on Sunday, July 26.

At a film clinic interesting cases were presented by Dr. Halley, Dr. Rypins, and Dr. Henley.

Dr. P. G. Melnick and Mr. Albert Bachem discussed "The Time Factor in the Irradiation of Malignant Tumors," and Dr. A. H. Arneson presented a paper on "Radiation Therapy in the Treatment of Malignant Diseases."

MIDSUMMER RADIOLOGICAL CONFERENCE, DENVER

This program was designed to better acquaint the entire medical profession with the uses of radiology in diagnosis and treatment. The Conference was sponsored by the Denver Radiological Club. The sessions took place Aug. 5, 6, and 7, 1936. There was no registration fee. All meetings were held in the Venetian Gardens, Hotel Shirley-Savoy, Denver.

The following were guest speakers:

EUGENE P. PENDERGRASS, M.D., F.A.C.R.
Assistant Professor of Radiology, School of Medicine, University of Pennsylvania, Philadelphia

JOHN D. CAMP, M.D., F.A.C.R.
Assistant Professor of Roentgenology, Mayo Foundation, University of Minnesota; Associate in Roentgenology, Mayo Clinic, Rochester, Minn.

J. M. MARTIN, M.D., F.A.C.R.
Professor of Radiology, Baylor University, Dallas, Texas

CLYDE K. EMERY, M.D., M.R.C.S., L.R.C.P.
Assistant Professor of Radiology, California Institute of Technology, Pasadena, Calif.; Director of Radiation Therapy, Cedars of Lebanon Hospital, Hollywood, Calif.

The following were visiting speakers from the Radiological Club of Omaha:

HOWARD B. HUNT, M.D., F.A.C.R.
Associate Professor of Radiology, University of Nebraska Medical School, Omaha, Nebr.

ANDERS P. OVERGAARD, M.D., F.A.C.R.
Omaha, Nebr.

ALBERT F. TYLER, M.D., F.A.C.R.
Attending Radiologist, St. Joseph and Immanuel Hospitals, Omaha, Nebr.

T. TENNYSON HARRIS, M.D.
Roentgenologist, Clarkson Hospital, Omaha, Nebr.

JAMES F. KELLY, M.D., F.A.C.R.
Professor of Radiology, Creighton University School of Medicine, Omaha, Nebr.

EDWARD W. ROWE, M.D., F.A.C.R.
Radiologist, Lincoln Clinic; Radiologist, Bryan Memorial Hospital, Lincoln, Nebr.

The following papers were presented:

Recent Advances in Diagnostic Radiology. ERNST A. SCHMIDT, M.D., Denver.

The Small Intestine. EUGENE P. PENDERGRASS, M.D., F.A.C.R., Philadelphia.

The Gastro-intestinal Tract of Children. JOHN S. BOUSLOG, M.D., Denver.

Discussion opened by JOHN D. CAMP, M.D., F.A.C.R., Rochester, Minn.

Osteoporosis and its Importance in Medical Diagnosis. JOHN D. CAMP, M.D., F.A.C.R., Rochester, Minn.

The Physician's Responsibility to the Cancer Patient. J. M. MARTIN, M.D., F.A.C.R., Dallas, Texas.

Symposium on Gastro-intestinal Disease. Arranged by the Radiological Club of Omaha; Chairman, HOWARD B. HUNT, M.D., F.A.C.R., Omaha.

Roentgen Diagnosis of Lesions of the Esophagus. ANDERS P. OVERGAARD, M.D., F.A.C.R., Omaha.

The Value of the True Lateral Examination of the Duodenum. ALBERT F. TYLER, M.D., F.A.C.R., Omaha.

X-ray Diagnosis of Lesions of the Colon. T. TENNYSON HARRIS, M.D., Omaha.

The Value of the Preliminary Film without Opaque Media in the Diagnosis of Abdominal Conditions. JAMES F. KELLY, M.D., F.A.C.R., Omaha.

Radiography of the Biliary Tract, Before, During, and Following Operation. HOWARD B. HUNT, M.D., F.A.C.R., Omaha.

Malignancy Originating in the Small Bowel. EDWARD W. ROWE, M.D., F.A.C.R., Lincoln.

Discussion opened by LORENZ W. FRANK, M.D., President of the Denver Internists' Club, Denver.

Round Table Discussion of the Problems of Diagnostic Radiology, answered by our distinguished guests: Chairman, W. W. WASSON, M.D., Denver.

Symposium on Diagnostic Radiology. S. B. CHILDS, M.D., presiding, Denver.

Roentgenologic Findings in Patients with Sciatica and Low-back Pain. JOHN D. CAMP, M.D., F.A.C.R., Rochester, Minn.

Discussion opened by HENRY W. WILCOX, M.D., President of the Orthopedic Club of Denver; Associate Professor of Orthopedic Surgery, University of Colorado Medical School, Denver.

Heart Measurements. ELIZABETH H. NEWCOMER, M.D., and NATHAN B. NEWCOMER, M.D., Denver.

Discussion opened by T. D. CUNNINGHAM, M.D., Denver.

Review of Year's Progress in Radiation Therapy. PAUL R. WEEKS, M.D., Denver.

Radiation Therapy in the Treatment of Carcinoma of the Intra-oral Cavity, Larynx, and Pharynx. J. M. MARTIN, M.D., F.A.C.R., Dallas, Texas.

The Management of Carcinomas of the Breast. CLYDE K. EMERY, M.D., M.R.C.S., L.R.C.P., Pasadena, Calif.

Discussion opened by W. W. WASSON, M.D., Denver.

Round Table Discussion of Therapeutic Radiology: Chairman, SANFORD WITHERS, M.D., Denver.

Chaoul Therapy as Practised in European Clinics. EUGENE P. PENDERGRASS, M.D., F.A.C.R., Philadelphia.

Radiation Therapy as a Rational Treatment for Fibroids, Menorrhagia, Ovarian Dysfunction, Inflammations, Fungus and Pyogenic Infections, etc. LEONARD G. CROSBY, M.D., Denver.

The Place of Super-voltage X-ray in the Treatment of Malignancies. CLYDE K. EMERY, M.D., M.R.C.S., L.R.C.P., Pasadena, Calif.

Discussion opened by FRANK B. STEPHENSON, M.D., Denver.

CANCER INSTITUTE

The Medical School of the University of Wisconsin, at Madison, conducted a Cancer Institute from Sept. 7 to 9, 1936. In the Section, "Cancer and Inheritance," were the following papers:

"The Influence of Extrinsic Factors in the Development of Induced Tumors in Animals," by Dr. Leiv Kreyberg, University of Oslo, Oslo, Norway.

"The Influence of Intrinsic Factors in the Development of Tumors in Mice," by Dr. C. C. Little, Director, Roscoe B. Jackson, Laboratory of Cancer Research, Bar Harbor, Maine.

"Familial Occurrence of Cancer," by Dr. Madge T. Macklin, Associate Professor of Histology and Embryology, University of Western Ontario, London, Ontario.

"Hormones and the Development of Atypical Growths and Malignant Tumors," by Dr. Edgar Allen, Professor of Anatomy and Chairman of Department, Yale University Medical School, New Haven, Conn.

"Carcinogenic Substances in the Production of Tumors in Laboratory Animals," by Dr. H. B. Andervont, biologist, U. S. Public Health Service, Boston.

There were Round Table Discussions as follows:

"Diagnostic Problems in the Recognition of Early Cancer," under the leadership of Dr. S. P. Reimann, of the Lankenau Hospital and Graduate School of the University of Pennsylvania; by Dr. Emil Novak, of Johns Hopkins Medical School, and by Professor Henri Coutard, of the Radium Institute, Paris.

"Genetics—Inheritance and Cancer," by Dr. Leiv Kreyberg, Dr. C. C. Little, and Dr. Madge T. Macklin. "Filterable Viruses and Cancer," under the leadership of Dr. J. B. Murphy, Director of Cancer Research, Rockefeller Institute of Medical Research, New York City, by Professor B. M. Duggar, of the University of Wisconsin.

"Surgery and Irradiation in the Treatment of Cancer," under the leadership of Professor Henri Coutard, by Dr. G. Failla and Dr. Emil Novak.

"Cytology of Malignant Neoplasms," under the leadership of Dr. James Ewing, by Dr. S. P. Reimann and Dr. Warren H. Lewis.

"Etiology of Cancer," under the leadership of Dr. H. B. Andervont, by Dr. J. B. Murphy and Dr. Edgar Allen.

Dr. James Ewing, of Cornell University Medical College and Memorial Hospital, New York City, broadcast a talk on "Cancer, a Public Health Problem," and Dr. C. C. Little, speaking for the American Society for the Control of Cancer, on "A Program for the Control and Prevention of Cancer."

The following papers were read:

"The Influence of Wave Length on the Biological Action of Radiation," by Dr. Gioacchino Failla, physicist, Memorial Hospital, New York City.

"The Reaction of Tissue Cells to Irradiation," by Professor Henri Coutard, Radium Institute, Paris.

"Tissue Culture in the Study of Cancer," by Dr. Warren H. Lewis, Carnegie Institution of Washington, Baltimore.

"The Biology of the Cancer Cell," by Dr. S. P. Reimann, Philadelphia.

"Filterable Viruses in Malignant Neoplasms," by Dr. J. B. Murphy, New York City.

At the joint meeting with the State Medical Society of Wisconsin the following papers were read: "Biopsy in the Recognition and Treatment of Early Malignancy," by Dr. James Ewing; "The Relation of Filterable Viruses to Malignant Neoplasms," by Dr. J. B. Murphy; "The Effect of Bacterial Products on the Growth of Malignant Tumors," by Dr. H. B. Andervont; "The Recognition and Treatment of Early Malignant Lesions of the Uterine Cervix," by Dr. Emil Novak; "Treatment of Cancer of the Breast," by Professor Henri Coutard; "The Genetic and Constitutional Aspects of Spontaneous and Induced Tumors," by Dr. Leiv Kreyberg; "Glandular Dysfunction and the Development of Malignant Tumors," by Dr. Edgar Allen; "A Study of the Occurrence of Cancer in Different Individuals of the Same Family," by Dr. Madge T. Macklin.

BOOK REVIEWS

"RÖNTGENATLAS DER STAUBLUNGENERKRANKUNGEN DER RUHRBERGLEUTE," by VON DR. G. SCHULTE, Leiter der Röntgenabteilung am Knappschafts-Krankenhaus, Recklinghausen, unter Mitarbeit von Dr. K. Husten, Prosektor der Ruhr-Knappschaft am Knappschafts-Krankenhaus Essen-Steele. A volume of 141 pages, 153 illustrations. Published by Georg Thieme, Leipzig, 1936. Price, 23.40 RM.

This is another of the valuable supplements issued by the "Fortschritte auf dem Gebiete der Röntgenstrahlen" and deals exclusively with silicosis as observed in the miners of the Ruhr district in Germany. The short introduction details the character of the material on which the atlas is based. There were about 115,000 workers in stone in this region in 1933. In the period of 1930–1933 there were 1,400 deaths from silicosis or its complications in Dortmund alone.

Schulte examined 10,867 workers between 1927 and 1935, while Husten contributes the data on the pathology of the disease, many of the cases having come to autopsy.

The discussion of etiology, pathology, and development of silicosis is in general in conformity with what has already been written on the subject. The authors believe a colloidal suspension of the silica with the body fluids is the chief causative agent, although they admit the mechanical factor as well. Their classification is conventional although they seem to interpret cases with rather marked involvement as being in the first or second stage. Interesting curves of the relationship of the degree of involvement to the length of the time of exposure to dust are shown. There is a considerable discussion of predisposition to silicosis.

The authors emphasize strongly the importance of tuberculosis in producing rapid advance of the disease. They are convinced that silicosis predisposes to tuberculosis and record 70 per cent of the deaths as due to this complication.

The roentgen findings are described in some detail, with observations on differential diagnosis. The latter, however, is very weak and it is apparent that Schulte relies largely upon clinical evidence for eliminating other diseases. He emphasizes strongly, however, the relative absence of clinical signs in pure silicosis and the crucial importance of roentgen studies in diagnosis. The necessity for roentgen examination of the stone worker before employment and at frequent intervals afterward is repeatedly emphasized.

The atlas itself is divided into three parts containing a large number of very well produced plates; in many instances enlargements of a small portion of the lung-field are also shown. These are most instructive and the films as a whole are well selected and very illuminating.

In the first portion are shown normals, first, second, and third stage silicosis, silico-tuberculosis, one case with pneumothorax, one with lung gangrene. It is notable that the authors reproduce only one case of third stage silicosis in which tuberculosis was not present.

The second section concerns itself with the progress of the disease. Twenty-six cases are illustrated with two or three plates of each at various intervals to show the changes in the roentgenogram. Particular emphasis here is placed upon the progressive nature of the disease even when exposure to dust has ceased, and the importance of tuberculosis in causing rapid progression.

The third section is most inadequate as a presentation of differential diagnosis. Only five cases are shown and these are fairly obvious. The more difficult problems in differential diagnosis are not touched upon.

On the whole, the atlas presents a satisfactory group of cases to which reference could be made for the study of silicosis. Although it is narrow in its scope, referring only to stone workers, the excellence of the reproductions makes it a valuable medium for the study of the disease.

"L'Annee Electro-radiologique Deuzieme Annee." By Morel-Kahn and collaborators. Second year (1934–1935). A volume of 266 pages, with 38 figures in the text. Published by Masson et Cie, 120 Boulevard St. Germain, Paris. Price, 40 francs.

The second issue of "The Year in Electro-radiology," like the first, consists of articles by French authorities on those electro-radiologic subjects which are of greatest interest or importance to the French surgeon, internist, or general practitioner. As before, the book is in four parts, diagnostic radiology, general radiotherapy, electrology, and a report of various meetings. The material is well and briefly presented, but not too well illustrated. Each section is followed by a short bibliography in which one notices almost complete omission of non-French references. One wonders what may be the value of this sort of year book to the American radiologist.

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W. H. Gillentine, M.D., of New Orleans.
J. E. Habbe, M.D., of Milwaukee, Wisc.
H. W. Hefke, M.D., of Milwaukee, Wisc.
Hans A. Jarre, M.D., of Detroit, Mich.
Davis H. Pardoll, M.D., of Chicago
Ernst A. Pohle, M.D., Ph.D., of Madison, Wisc.
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APPARATUS

A Dental Film-holder with Centering Device. Werner Rettig. München. med. Wchnschr., April 24, 1936, **83,** 683, 684.

An ingenious and inexpensive device is described, for maintaining a dental film in position for intra-oral exposures, and affording accurate and simplified direction of the x-ray beam. The advantages are particularly evident in ill or nervous patients, who are unable to co-operate in the ordinary method of holding the film packet in position by finger or bite blocks. Accurate visualization of the entire tooth is obtained, regardless of anomalous configuration of maxilla or mandible, or peculiarly directed teeth, with a minimum of distortion due to the bending of the film. Briefly, the device consists of an adjustable forcep holding the film packet firmly, with a metal rod affording the direction of angulation of the x-ray tube. The patient holds the forcep firmly against the crown of the teeth to be examined.

WILLIAM R. STECHER, M.D.

ARTERIOGRAPHY

Buerger's Disease; Arteriography; Arteriectomy. L. Dejardin. Bruxelles-méd., May 24, 1936, **16,** 1138–1141.

In a case of Buerger's disease, thorotrast was used to confirm the diagnosis and to establish the status of the circulation in the right forearm of a patient who had, two years previously, lost his left leg by amputation, for this same disease. Following arteriography, the diseased artery was resected and the author reports relief of pain and a favorable thermal reaction of over a year's duration.

JOSEPH DAUKSYS, M.D.

BLOOD CHANGES

The Effect of Roentgen-ray Irradiation on Platelet Production in Patients with Essential Thrombocytopenic Purpura Hemorrhagica. Stacy R. Mettier, Robert S. Stone, and Katherine Purviance. Am. Jour. Med. Sci., June, 1936, **191,** 794–807.

The authors report their findings in seven cases, divided into three groups. The first group, acute recurring thrombocytopenia (four cases), showed a decided increase in the number of blood platelets beginning within from twenty-four to forty-eight hours after the institution of radiation therapy, up to 500,000 within nine days. With the increase in the number of platelets there was an amelioration of symptoms. In one case there was a remission after seven months, with recurrence of symptoms. A second series of treatments resulted in clinical improvement with an increase in the platelets to over 300,000.

The second group, chronic thrombocytopenia with recurring purpura (two cases), showed a temporary increase in the number of platelets which decreased shortly after the cessation of radiation therapy.

In the third group there was one case of an acute fulminating purpura, which showed no response to radiation therapy. The patient died five days after the onset of symptoms.

The authors used the following technic: 200 kv.; 15 ma.; target-skin distance, 50 cm.; filtration, 0.2 mm. tin, 0.25 mm. copper, 2.0 mm. aluminum. The radiation delivered 28.2 r per minute, measured without back-scattering. The size of the field varied from 100 to 200 sq. cm., depending upon the size of the patient as well as the size of the spleen.

In six cases the radiation was directed to the spleen, using three portals, and in one case, in which a splenectomy had been performed, to the long bones. The patients received 200 r to each portal, and only one portal was radiated daily. The total dosage delivered was 1,200 r.

When a second series of treatments was necessary 300 r were given daily, the total dosage up to 3,300 r.

HENRY K. TAYLOR, M.D.

BONE DISEASES (DIAGNOSIS)

Hypertrophy of the Palpebral Tarsus, the Facial Integument, and the Extremities of the Limbs Associated with Widespread Osteo-periostosis: A New Syndrome. J. N. Roy. Canadian Med. Assn. Jour., June, 1936, **34,** 615–622.

The author describes in detail the findings in an adult male who had been under observation for ten years. The patient presented:

(1) Bilateral hypertrophy of the palpebral tarsus.

(2) Hypertrophy of the skin, involving the face, eyelids, and with a symmetrical hypertrophy of the lower third of the forearm and legs, wrists, hands, ankles, and feet.

(3) Atypical osteo-periostosis involving most of the bones of the skeleton.

An osseous dystrophy with resorption and calcareous regeneration is manifested by an increased width of long bones, particularly at the distal ends; the medullary canal is widened at the expense of the cortex; the compact bone presents a reticular appearance; the outline is irregular and nodular, osteophytic outgrowths in certain regions due to an ossifying periosteal hyperplasia which envelope the bone from one diarthrodial cartilage to the other, including the extra-articular part of the epiphysis. This type of lesion involved the clavicles, the long bones of the upper and lower extremities, the metacarpals and metatarsals, and phalanges of the hands and feet. The lower ends of the ulnas showed hypertrophy of the spongy bone. The scapulæ presented irregularities in contour with destruction of trabecular structure. The iliac bones were not markedly affected—the shapes were not quite normal. The patellæ were enlarged by numerous small exostoses, and presented a woolly appearance. The vertebral column was also involved—bodies deformed and presenting osteophytes. The ribs were normal. The skull showed an increase in the external diameters,

with a thick vault and large frontal sinuses. The sella turcica was normal.

The author differentiates this lesion from (1) acromegaly, (2) Paget's, (3) von Recklinghausen's, (4) sclerosing osteitis of Albers-Schönberg, (5) melorheostosis, (6) osteopecilia, (7) pneumo-chondro-dystrophy of Pierre Marie, (8) infection, and (9) syphilis.

Sections of the skin and palpebral tarsus were studied microscopically.

The author believes that the lesion is a hyperplastic and degenerative disturbance of certain connective tissues (bones, periosteum, palpebral tarsus, skin and subcutaneous tissues of face and extremities) due to an endocrine disturbance involving the parathyroid and pituitary glands. HENRY K. TAYLOR, M.D.

THE BREAST (BENIGN)

The Roentgen Therapy of Tuberculosis of the Breast. R. Glauner. Röntgenpraxis, January, 1936, **8,** 38–42.

Surgery has been and is the treatment of choice in tuberculosis of the breast. The author has seen three proved cases in Grashey's Institute, in Cologne, and treated them with roentgen rays. The technic consisted of small repeated doses (180 kv., filtered by 0.5 mm. Cu), 150 r per treatment, repeated at intervals of three weeks. Between 180 and 960 r had to be given to achieve clinical cure. The results of roentgen therapy in three reported cases was remarkably good. The patients have been symptom-free for three, twelve, and sixteen months. The author is of the opinion that a trial irradiation of tuberculosis of the breast is indicated.

H. W. HEFKE, M.D.

BREAST CANCER

The Radiological Management of Cancer of the Breast. Richard Dresser and Valmore A. Pelletier. New England Jour. Med., April 9, 1936, **214,** 720–723.

The authors analyze a series of 600 cases, selected from representative cancer clinics. In the first group they place the primarily operable cases. A lateral view of the skull and dorsal spine and an anteroposterior view of the lumbar spine and pelvis, including the upper ends of the femora, and a postero-anterior view of the chest are considered as sufficient to rule out metastasis. Surgery eradicates the cancer in 80 per cent of cases in this group. Those who die succumb to metastases; consequently the authors deem it unwise to subject the entire group to the hazard of local radiation when not more than 20 per cent will be benefited. Post-operative radiation is recommended in simple amputation of the breast without dissection of the axilla, when gross or microscopic disease is present in the axillary nodes, and in women who have not passed the menopause.

Sixty per cent of all cases belong in Group II (inoperable). Two hundred kilovolt peak roentgen rays with a filter of 0.5 mm. copper, a total of about 3,400 r units, are cross-fired into the breast, axilla, and supraclavicular region over a period of from eight to ten days. Radiation is of little benefit when used on a metastasis, but it has an analgesic effect in cases with involvement of the spine.

Group III covers post-operative recurrences. Lesions of this type, when small, respond well to a maximum of 1,800 r units given over a period of from a week to ten days.

Group IV includes cancer of the breast in young women. Radical mastectomy gave 15 per cent three-year cures in this group. Cancer of the breast progresses with unusual rapidity during pregnancy and bears some relation to ovarian function. Castration by means of a dose of 600 r to the front and back of the pelvis, using a 15 by 15 cm. portal at a distance of 50 cm., produces a definite regression of bony metastasis in 30 per cent. The danger of future pregnancy alone justifies this procedure, although results in a majority of cases have been encouraging.

W. H. GILLENTINE, M.D.

BRONCHIECTASIS

The Importance of Early Diagnosis in Bronchiectasis: A Clinical and Roentgenologic Study of One Hundred Cases. John T. Farrell, Jr. Jour. Am. Med. Assn., Jan. 11, 1936, **106,** 92–96.

The author presents a clinical and roentgenologic study of 100 cases, 52 males and 48 females. Of the total number, 77 were 30 years of age or under when they first came under observation: 22 were in the first decade, 28 in the second, and 27 in the third. It was determined roentgenographically that in 41 patients the disease involved the left lung; in 23 it involved the right lung, and in 36 it was bilateral. Eighteen patients had had symptoms for less than one year, 32 from one to five years, 13 from six to ten years, 15 from eleven to twenty years, and two for more than twenty years. Seventeen patients had had the disease from infancy.

In 45 cases the onset was secondary to some disease of the respiratory tract; in 12 cases the onset followed one of the diseases of childhood, and the inhalation of a foreign body into the bronchus was the cause in four. In two, x-ray evidence of bronchiectasis was associated with asthma.

Ninety-three cases were studied bronchoscopically and in 77 iodized oil was instilled for pneumonography. Eighty-four of these presented evidence of inflammatory changes in the bronchial tree: in 15 tracheo-bronchitis; in 69 there was actual suppuration and pus was aspirated. Nine patients had bronchoscopic evidence of occlusion; in three the narrowing was due to extrabronchial pressure and in the remainder it followed intrabronchial narrowing. In three there was scar formation; in two cases an adenoma was found, and in one a papilloma.

Only 21 per cent of 66 patients whose sinuses were studied roentgenographically were normal; 24 per cent of these had marked disease, in most cases a pansinusitis.

Roentgenographic and bronchoscopic examination are essential for early diagnosis. Characteristic pneu-

mographic changes are necessary for indisputable proof of the existence of the disease.

CHARLES G. SUTHERLAND, M.B. (Tor.).

CANCER (DIAGNOSIS)

Pulmonary Carcinoma and Pulmonary Abscess as Represented in Tomographic Roentgenograms. H. Chaoul and K. Greineder. Fortschr. a. d. Geb. d. Röntgenstrahlen, March, 1936, **53,** 232–239.

The most characteristic symptoms of pulmonary carcinoma are the central tumor nucleus, irregular narrowing of the bronchus, and concomitant atelectasis. Even density of the tumor nucleus and infiltration radiating into the periphery, as well as irregular central degeneration, may be recorded as further symptoms. Tomograms are unusually well suited to the demonstration of these symptoms.

Signs of abscess are not quite so typical and characteristic. The opacity is more mottled, the area of decay more rounded, oval, and smoother, often multilocular. Irregular narrowing of a bronchus never occurs in a draining abscess and peripheral atelectasis is most rare.

Tomography can be a valuable aid in the differentiation between pulmonary neoplasm and abscess formation.

H. A. JARRE, M.D.

The Roentgenologic Demonstration of Tumors Perforating into the Trachea. E. Saupe. Röntgenpraxis, March, 1936, **8,** 156–159.

A direct invasion of the trachea by neighboring carcinomas is not as often seen as displacement of the trachea by the tumor. Two cases are described: one, of an esophageal cancer protruding into the lumen of the trachea. The trachea was shown covered by barium which had been accidentally aspirated during the examination. In the second case a tumor mass (from a thyroid carcinoma) could be seen in the tracheal air-space.

H. W. HEFKE, M.D.

Diagnostic Criteria of Colonic Cancer. Curtice Rosser. Jour. Am. Med. Assn., Jan. 11, 1936, **106,** 109–111.

The author reviewed 100 consecutive cases and noted a definite location coincidence in colonic tumors. More than half involved the descending colon and the sigmoid, one-fourth the cecum and ascending colon, and approximately one-fifth the mid-colon.

Cancer of the cecum and ascending colon simulated appendicitis in more than two-thirds of the cases. Constipation was a feature of growths in the mid-colon. Constipation and colic characterized a majority of the neoplasms affecting the descending colon and sigmoid; about one-fourth the patients of the series complained of continuous diarrhea.

Cancer of the rectosigmoid presented an accentuation of the symptoms seen in other parts of the left colon, with a sharp rise in the number of patients who observed blood in the stool and a paradoxical decrease in the degree of anemia. Anemia, indigestion, localized pain not relieved by bowel movements, and palpable tumor were all highest in incidence in the right colon and decreased as the location approached the rectum.

Constipation, colic, and obstruction were the predominant features of colonic cancer in general.

Friedenwald, in the discussion, stressed digital as well as proctoscopic examination, augmented by roentgen studies in diagnosis.

CHARLES G. SUTHERLAND, M.B. (Tor.).

CANCER (THERAPY)

Roentgen Therapy in Malignancy: Its Indications and Limitations. Frank E. Butler and Ivan M. Woolley. Northwest Med., May, 1936, **35,** 172–175.

The authors comment on the fact that in treating malignancy they are treating a symptom of an obscure disease, and that a factor in the outcome is the resistance of the patient to his or her particular malignancy. Prognosis depends upon (1) age of patient, (2) type of neoplasm, (3) location of lesion, (4) agent employed.

The value of roentgen therapy in malignancy is briefly discussed under the following topics: (1) Malignancies that may be expected to respond to irradiation without the aid of surgery; (2) Malignancies that are best treated by a combination of surgery and irradiation; (3) The inoperable malignancies; (4) Malignancies which fail to give worth while response to roentgen therapy; (5) Metastatic malignancy; (6) Recurrent malignancy following surgery.

HENRY K. TAYLOR, M.D.

The Lympho-epithelial Carcinoma. R. Baumann-Schenker. Strahlentherapie, 1936, **55,** 369.

The author analyzed in detail the 23 cases of *true* lympho-epithelial carcinoma seen in 1928–1935 at the Schinz Institute in Zürich. There were 17 carcinomas in the epipharynx, three in the mesopharynx, and two in the hypopharynx; one was located in the trachea and probably started from a residual thymus gland. The differential diagnosis was sometimes difficult because lymphosarcoma, transitional-cell carcinoma, and endothelioma may present similar histologic pictures. Radiation therapy is, according to the author, the method of choice. Technic: 180 kv., 3 mm. Al or 0.5 mm. Cu if single massive doses were applied. Since 1929 the protracted fractional dose method (Coutard) has been used; the original filter of 1 mm. Cu + 1 mm. Al was changed in 1933 to a Thoraeus filter and in 1934 to 2 mm. Cu + 1 mm. Al. Residual masses found after roentgen therapy were treated by applications of radium as described by Berven.

Of the 23 cases, 18 were alive and 14 free from symptoms in December, 1935, *i.e.*, six months after the last

treatment. Most of these cases had not lived for the three-year cure period. Of 9 patients, 22 per cent who had been treated three years before were alive at the time of publication. Three tables are appended giving condensed clinical data on all observed patients.

ERNST A. POHLE, M.D., Ph.D.

A Technic for Roentgen Irradiation of Inaccessible Cancer of the Skin. Howard H. Ashbury. Am. Jour. Roentgenol. and Rad. Ther., January, 1936, **35**, 93–95.

An impression of the lesion and surrounding areas is made in dental compound. After the compound is hardened, sheet lead one-sixteenth inch thick is fitted over the inner surface of it, thus producing a mask of the part under consideration. A hole is then cut over the part to be treated and the mask strapped over the region. The method is especially useful about the eye. Detailed directions are incorporated in the paper.

S. M. ATKINS, M.D.

Discussion on Short Distance Low Voltage X-ray Therapy. H. Chaoul, J. M. Woodburn Morison, and J. F. Bromley. Proc. Roy. Soc. Med., Sect. Radiology, May, 1936, **29**, 791–808.

The paper opens with a discussion by the first-named author of a new development in x-ray therapy which aims to be a substitute for the use of radium. The technic is as follows:

(1) Short focus-skin distance (2 in.); (2) low voltage roentgen rays (60 kv.); (3) filtration (0.2 mm. Cu); (4) small fields—surrounding normal tissue protected; (5) fractional dose (total treatment from two to four weeks); (6) daily doses from 300 to 500 r, administered in from 2 to 4 min.; (7) total dose from 5,000 to 10,000 r.

The above is accomplished with a monopolar shockproof x-ray tube, measuring 2.5 × 15 centimeters.

A depth dosage curve shows 56.2 per cent of the radiation at 0.5 cm.; 43.7 per cent at 1 cm.; 28.1 per cent at 2 cm.; 18.7 per cent at 3 cm., and 12.5 per cent at 4 cm. (F.S.D., 5 cm.; field, 12.56 sq. cm.; 60 kv.; 4 ma; 0.2 mm. Cu measured in water).

This method has been employed in:

(1) Skin carcinoma, 109 cases with 93.5 per cent success

(2) Lip carcinoma, 26 cases with 88.5 per cent success

(3) Oral cavity carcinoma, 28 cases with 53.6 per cent success

(4) Carcinoma of glandular organs and the rectum, 45 cases with 64.4 per cent success

(5) Melanoblastoma, 12 cases with 83.3 per cent success

(6) Sarcoma, 11 cases with 63.6 per cent success.

Of the 231 cases, six were under observation over four years, 22 up to four years, 32 up to three years, 69 up to two years, and 59 up to one year. Of the total group, 42 presented recurrences or were not healed and one patient died from another cause. The author claims that 81 per cent of the cases under observation are absolutely free of symptoms, and that this result surpasses the results obtainable from radium.

This method permits treatment of all suitable cases at low cost, and particularly where there are insufficient quantities of radium.

The method is contra-indicated in cases with large tumors or with many metastases, and in those cases which have received intensive x-ray or radium treatment.

Professor J. M. Woodburn Morison claims that this method has a useful place in the treatment of malignant diseases, and should not be looked upon as a rival method of radiation therapy, but as an additional method suitable for accessible lesions. His results have been similar to Professor Chaoul's and he has treated cases with epithelioma of the lips, floor of the mouth, alveolus, tongue, cheek, palate, tonsil, and pharynx, recurrent nodules in cancer of the breast, cancer of the rectum after operation—accessible cancers or cancers made accessible by operation.

Dr. J. F. Bromley has used the Chaoul tube in 70 cases with the following results: healed, 22; improved, 37; worse, 9; died from cancer, one; died from other causes, one. He stresses the convenience with which it can be used for the localized ulcerating tumor, or localized excrescence in awkward situations, as auricle, external auditory meatus, canthus of eye, ala of nose, angle of mouth, etc.

HENRY K. TAYLOR, M.D.

CONTRAST MEDIA

Demonstration of the Seminal Vesicles on Roentgenograms by Iodipin. Herbert Junghanns. Röntgenpraxis, January, 1936, **8**, 21–24.

Roentgenograms of the seminal vesicles after filling with iodized oil have been used occasionally for diagnostic purposes. The author injected the vas during operation for sterilization. The normal roentgen appearance is described.

H. W. HEFKE, M.D.

Visualization of the Cerebral Vessels by Direct Intracarotid Injection of Thorium Dioxide (Thorotrast). Julius Loman and Abraham Myerson. Am. Jour. Roentgenol. and Rad. Ther., February, 1936, **35**, 188–193.

The diagnosis of certain cerebral conditions, especially neoplasm and abnormalities of the vascular tree, can probably be definitely aided by intracranial arteriograms and phlebograms.

Because of the difficulties of exposing and ligating the carotid artery into which the solution (thorotrast) is injected, the authors have devised a technic whereby the artery is directly injected. The region of the common carotid artery (level of cricoid cartilage) is infiltered with novocaine. In unco-operative patients, preliminary sedation with sodium amytal is recommended. In the supine position, with the head hyper-

extended, thus fixing the artery, and the fingers placed as a guide over the line of maximum impact, the puncture is made by a $1^1/_2$ in., No. 18–19 gauge needle, connected by a three-way stopcock to a 20 c.c. syringe. The stopcock is, in turn, connected to a glass tube and stiff rubber tubing, both of which are filled with citrate, and finally to an aneroid Tycos manometer. Only when there are free and wide oscillations of the manometric needle and drop of the pressure with compression of the artery below the puncture, to be followed by immediate return to normal with removal of the compression, is the syringe disconnected and replaced by one containing thorotrast.

As an assistant compresses either the homolateral carotid at the root of the neck or, still better, both internal jugulars over the sternomastoid muscles, the thorotrast is injected rapidly. Lateral views of the skull are taken immediately after injection of 10 c.c. A fair phlebogram may be made three to four seconds later. No harm need be expected from these injections, even when there is some spilling into the tissues, including the brain.

S. M. ATKINS, M.D.

Thorium Hydroxide Sols as Opaque Media in Roentgenography. Thomas O. Menees and J. D. Miller. Am. Jour. Roentgenol. and Rad. Ther., February, 1936, **35,** 194–199.

Thorium hydroxide sols form an opaque coagulum with proteins in an alkaline medium. The coagulum forms a coating on the wall of a viscus, thus outlining the mucous membrane in relief. The medium does not coagulate in an acid medium or with secretions poor in proteins, thus making them unsuitable for the stomach, nasal accessory sinuses, esophagus, bladder, or urethra. Its chief use is in the uterus, sinus tracts, and in fistulæ.

In the uterus the mucosal pattern is demonstrated, as well as such conditions as hyperplasia, hypoplasia, mucous polyp, endrometrioma, carcinoma, submucous and intramural myoma. Pregnancy and pelvic inflammation are the only contra-indications to the use of this method. The injection is made with the cervical canal wide open.

S. M. ATKINS, M.D.

THE CRANIUM

Oxycephaly, with the Report of Two Cases in a Brother and Sister. David L. Klein and A. E. Childe. Canadian Med. Assn. Jour., April, 1936, **34,** 397–399.

The authors describe two cases of oxycephaly and present x-rays showing exaggerated convolutionary markings, thinness of the vault of the skull, upward projections at the bregma, the outward bulging of the temporal region, and shallow orbital cavities.

W. H. GILLENTINE, M.D.

Metabolic Craniopathy. Sherwood Moore. Am. Jour. Roentgenol. and Rad. Ther., January, 1936, **35,** 30–39.

This condition refers to a hyperostosis of the skull, apparently due to faulty metabolism, and accompanied by a distinctive clinical picture. Another group characterized by localized thinning of the skull which probably also belongs under this heading is not yet proven.

The hyperostoses are of two orders, one involving the compact bone of the inner table with later invasion of the diploë; the other being limited to the diploë. Again, this condition is divided into four types based on their location, namely: hyperostosis frontalis interna, hyperostosis calvariæ diffusa, hyperostosis fronto-parietalis, and nebula frontalis. All are bilaterally symmetrical and all four may be present in one individual.

Hyperostosis Frontalis Interna shows either nodular or sessile very dense cancellous bone deposited on the inner table of the squama frontalis and varying from that which is barely detectable to masses more than 1 cm. in thickness. The intracranial aspect has an outline, wavy in the nodular and regular in the sessile forms, and is smooth. There is no change of the skull externally. No progression or diminution has been noted in those individuals examined over a period of years.

Nebula Frontalis is seen as a triangular or ovoid area of density and thickness in the squama frontalis, with a broad base in the sagittal plane and, owing to its involvement of the diploë only, can be demonstrated in the lateral view only. Its variations are many and it does progress.

Hyperostosis Calvariæ Diffusa shows a general even increase in the volume and density of the diploë of the vault of the skull. Because of the density the roentgenogram lacks detail; the vascular grooves are deepened; the skull is enlarged internally but not externally.

Hyperostosis Fronto-parietalis is also diploic and roentgenologically the change is like the calvariæ diffusa and nebula frontalis except that the maximum thickening is at the central points of the squama of the frontal and parietal bones, producing thus an even gentle grooving at the coronal and sagittal sutures. This is the most indefinite and infrequent type.

All these may be due to an excess of calcium in the organism and clinically the symptom-complex is as striking as the roentgen findings, for with a few exceptions the patients had neurological and neuropsychiatric symptoms. The syndrome was a combination more or less constant of headache, obesity of the rhizomelic type, enlarged breast in the female, easy fatigue, muscular weakness, nervousness, tendency to worry and depression, dimness of vision, occasionally diplopia, epileptiform seizures, impairment of memory, and even definite cranial nerve involvement. Overgrowth of facial hair may occur in the female. The nerve and muscular weakness resembles in some respects chronic intoxications.

Treatment is as yet not definite but in cases in which metabolism can be shown to be at fault it should be combated and in cases in which pressure on vital areas is present the bone should be removed.

This study is based on an analysis of 193 cases available. Of 6,650 individuals roentgenographed, there were 229 of these cases, of which 225 were females.

S. M. ATKINS, M.D.

DERMATITIS

The Surgical Treatment of Chronic Radiation Dermatitis. Stuart Gordon. Canadian Med. Assn. Jour., June, 1936, **34,** 622–624.

The author quotes Porter's clinical grouping of patients with radiation dermatitis:

1. Those who have received a single therapeutic or diagnostic dose (may be due to individual idiosyncrasy; radiation to an area in which vascular damage is present, or intentional heavy dosage).

2. Those who have received repeated doses at intervals.

3. Personnel administering the treatment and who have suffered injury.

There are two clinical types, the acute and chronic ulceration. The acute one develops rapidly after exposure—an irregular shallow ulcer which is due to actual cell death, and if small may respond to local treatment. The chronic one, which may appear as late as twenty years following exposure, first presents a brownish pigmentation in the radiated area which fades in a year—telangiectases appear in the thin, dry, hairless skin—dark areas of thrombosis appear—the corium gradually thickens (itching and burning of involved area)—hyperkeratoses develop—tiny cracks appear in the skin and eventually ulceration supervenes which may undergo malignant changes.

The surgical treatment of the chronic lesion is directed to (1) relief of symptoms, (2) repair of deformity, and (3) removal of danger of malignant change. This is accomplished by adequate excision followed by some type of skin grafting.

HENRY K. TAYLOR, M.D.

THE ESOPHAGUS

A Method of Roentgen Diagnosis of Non-opaque Foreign Bodies in the Esophagus. Wendell G. Scott and Sherwood Moore. Jour. Am. Med. Assn., March 14, 1936, **106,** 906–908.

The most common foreign body of this type is a small piece of bone from a fowl or fish. These bones are usually fragments of the sternum or rib of a chicken, are incompletely ossified and calcified, the calcium content has been further removed by cooking, and they are relatively non-opaque to x-rays. Other foreign bodies are buttons, many of which are transparent to x-rays, or a firm bolus of food, especially meat, the latter sometimes halted by inherent lesions such as stricture or carcinoma, or extrinsic pressure from mediastinal tumor, aneurysm, enlarged thymus, hyoid, or left auricle.

The customary site of lodgment is at the level of the suprasternal notch, as it is normally the narrowest segment of the esophagus. Lesser constrictions occur at the introitus, at the level of the crossing of the left bronchus, and at the diaphragmatic pinchcock.

Films and fluoroscopic studies include the nasopharynx and the stomach. Anteroposterior and lateral views of the neck are made before resorting to the use of opaque media. Fluoroscopic visualization, using a thick suspension of barium sulphate in water, follows, with careful search for deviation or division of the stream or filling defect in the esophagus. When the patient has swallowed the barium, careful search is made for evidence of a residuum of it clinging to a foreign body. Failing in these examinations, the patient stands in front of the regular cassette changer and drinks a thin watery solution of barium through a glass tube in small, rapid swallows in an effort to maintain a continuous stream down the esophagus. Exposures are made in both the anteroposterior and right anterior oblique positions, the latter being preferred to a lateral view. The barium mixture coats the esophageal walls and, in meeting a foreign body, produces a constant filling defect. In addition, it coats the foreign body, which is demonstrated as a constant collection of opaque material within the lumen of the esophagus.

Esophagoscopy should be performed as soon as possible after the diagnosis.

CHARLES G. SUTHERLAND, M.B. (Tor.).

FISTULAS

Radiation Therapy of Anorectal Fistula. Delherm and Devois. Strahlentherapie, 1936, **55,** 137.

The authors recommend roentgen rays in the treatment of anorectal fistula. Technic: 120 kv., 3–8 mm. Al, 250 r once or twice per week. After from six to eight sittings a mild erythema usually appears. If necessary, a second series can be given after an interval of from three to four weeks.

An attempt was made to improve the results by the use of a secondary irradiator (copper); this was, however, not very successful. Injection of a quinine-urea solution into the fistula seems to be of benefit and acts as an adjunct to radiation therapy.

ERNST A. POHLE, M.D., Ph.D.

Carcinomatous Change in Fistula. Hans Hellner. München. med. Wchnschr., April 24, 1936, **83,** 689, 690.

In the case of a fistula resultant of osteomyelitis, of chronic pyogenic, tuberculous, or syphilitic origin, the chronic irritation may eventuate into carcinoma along the tract. Roentgenograms may show evidence of such, as sudden unexplained and rapidly progressing osteoclasis in a hitherto sclerotic osteomyelitic process. When the above is present in addition to increased fetid discharge, tissue should be obtained for section, and, if confirmed as carcinomatous, radical amputation should be instituted.

WILLIAM R. STECHER, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

What Does the Finding of Fluid Levels on Flat Films of the Abdomen Mean? A Contribution to the Differential Diagnosis of Intestinal Obstruction. Bernhard Becker. Röntgenpraxis, March, 1936, **8,** 145–156.

The importance of fluid levels on abdominal films, taken in the standing position or lying on the side, is recognized by radiologists and surgeons. This roentgenologic symptom does not mean intestinal obstruction in every case and critical consideration of other diseases which may cause it is necessary.

Fluid levels may be seen outside the intestinal tract; for instance, in gas-containing peritoneal pockets (peritonitis, perforated ulcer, etc.). Air-pockets may be seen post-operatively. The absence of Kerkring's folds or colonic haustra around these gas pockets indicates their extra-intestinal position.

Normally no fluid levels are seen in the small intestine of adults, except occasionally a gas bubble in the duodenal cap or in duodenal or jejunal diverticula. In infants, gas and fluid levels may be seen normally. Fluid levels in the colon, especially cecum and flexures, are fairly often demonstrable in healthy individuals. Acute infectious diseases of the intestines (enteritis, typhoid fever, dysentery) may cause formation of fluid levels and gas in the small intestines. Very rarely a pneumonia or severe decompensation of the heart might lead to similar findings. Opiates are known to cause a dilatation of the small intestines, and fluid levels found in patients after administration of morphine may be of no diagnostic significance at all. It is possible to show fluid levels in the colon and the distal ileum for a few hours after cleansing enemas. In questionable cases a barium enema, which is almost always possible, might be used to great advantage.

H. W. Hefke, M.D.

Graded Compression in the Exploration of the Digestive Mucosa. René Gilbert and Leon Babaiantz. Arch. d. Mal. de l'App. Digestif, May, 1936, **26,** 556–575.

Exploration of the gastro-intestinal mucosa with the aid of graded and localized compression is a supplementary form of examination used, not as a routine measure, but as indications arise, particularly when the clinical story appears clear-cut and routine examinations are fruitless. Good results are obtained and a niche is readily demonstrated, particularly in small ulcers of the lesser curvature and those of the posterior wall. In the presence of retention, particularly good results are obtained. Enlarged rugal folds, as in hypertrophic gastritis, and diminished folds, as seen in pernicious anemia, are very readily made out. In the duodenum the "niche de face" is easily demonstrated but in the jejunum poor results are obtained principally because of the super-imposition of various loops. In the terminal ileum and in the colon the mucosa is also well shown. Because of the ribs it is difficult to use compression at either colonic flexure or at the cardiac portion of the stomach.

The authors do not advise the use of compression following recent hemorrhage and in patients with sensitive abdomens and in the feeble and weak. In the presence of occult hemorrhage, compression is used cautiously and no accidents have been experienced in these cases. Excessive pressure is to be avoided, not only because of the possibility of harming the patient but also because it leads to error by obliterating the normal mucosal markings.

The observations reported result from an experience of two years in the study of the gastro-intestinal mucosa with the aid of localized and graded compression.

Joseph Dauksys, M.D.

The Effect of Foodstuffs on the Emptying of the Normal and Operated Stomach and the Small Intestinal Pattern. I. S. Ravdin, E. P. Pendergrass, C. G. Johnston, and P. J. Hodes. Am. Jour. Roentgenol. and Rad. Ther., March, 1936, **35,** 306–315.

The type of meal influences strongly the small intestinal pattern as seen roentgenologically and the progress of the meal through the gastro-intestinal tract in the normal as well as the pathological case. The writers' investigation indicates that the water and barium mixture exerts no specific influence on the gastric emptying time and this type of meal is, therefore, recommended as the standard one for the determination of pathological lesions of the gastro-intestinal tract. The variation in the appearance of the small intestinal pattern with different types of meals must be recognized by roentgenologists if they would correctly evaluate small bowel abnormalities.

The necessity for caution in the roentgenologic consideration of disturbances in the gastric motility of the recently operated stomachs is emphasized.

J. E. Habbe, M.D.

Radiological Examination of Stomach and Duodenum, with Special Reference to the Early Diagnosis of Cancer. K. Stuart Cross. British Med. Jour. Feb. 22, 1936, No. 3,920, 353–357.

The author emphasizes the importance of consultation between the internist and the radiologist, in order that the latter may be fully acquainted with all facts regarding the patient's clinical findings. The radiologist should be a physician and a pathologist with the ability to recognize the radiological manifestation of macroscopic disease. The necessity and value of re-examinations in all doubtful cases cannot be over-emphasized.

It should always be remembered that the essentials of efficient radiology are the knowledge, experience, and clinical acumen of the radiologist rather than impressive x-ray apparatus.

Gastric carcinoma is best detected by means of the roentgen ray. It is unfortunate that so many cases are

not seen until they are far advanced. The clinical histories of gastric carcinoma may be divided into two groups, as follows: (1) those in which the symptoms have arisen recently and suddenly in previously healthy individuals, and (2) those in which there has been dyspeptic trouble over a long period of time. It is estimated that there are from five to six patients in the first group for every one in the second. Statistics also show that by the time the patients reach x-ray examination and surgery, 50 per cent are inoperable. While the other 50 per cent are operated on, in only one-half of these cases is resection of the lesion justifiable. It is of interest likewise that in the group in which symptoms appear suddenly an average interval of from eight to ten months exists between the onset and the x-ray examination.

In the primary stages of carcinomatous involvement there may be nothing beyond narrowly limited infiltration of the stomach wall by cancer cells with localized induration. During peristaltic action this area tends to remain fixed in shape. Throughout the progress of an infiltrating, scirrhous type of carcinoma there may be no irregular projections of the malignant tissue into the lumen of the stomach, and therefore none of the classical "filling defects."

The mucosal pattern, visualized by a small quantity of suitable opaque medium, is considered of value in the study of the gastric lumen. Around the more or less acute simple ulcer the inflamed mucosa becomes greatly swollen. As the swelling subsides so does the depth of the ulcer crater. In contradistinction to the above is the local, irregular, heaped-up margin of neoplastic tissue around the malignant ulcer. Such a rugal study reveals the disappearance of the folds over an area of infiltration in early scirrhous malignancy and the abrupt discontinuity of the mucosal folds at the edges of a fungating mass.

The cardiac end of the stomach is difficult to examine as the rugal folds are coarse and complicated and this portion of the stomach cannot be palpated. Clinical symptoms may be slight if there is no involvement of the lower esophagus. However, Stewart and Illick have enumerated eleven diagnostic radiological signs of cancer of the fundus.

The radiological examination of the normal pyloric antrum shows the terminal line parallel to the base of the duodenal bulb. Localized irregularities in the form of the prepyloric gastric lumen, general narrowing of this segment, widening of the sphincteric zone with loss of the normal parallelism are significant findings.

The significance of deformation of the duodenal bulb or first portion of the duodenum is problematical. In the presence of acute symptoms of ulceration a deformity of this portion of the duodenum is considered as evidence of ulceration even though no crater is demonstrated. On the other hand, after the disappearance of symptoms the deformity which is still visible is interpreted as being due to cicatricial tissue. The author does not believe it justifiable to consider deformation as indicative of both conditions. The demonstration of the crater, however, is practically diagnostic of ulceration. The discovery of the "irritable cap," as manifested by intrinsic peristaltic activity, failure to retain the food received from the stomach, and the various degrees of spastic deformation may aid in the diagnosis.

Because of practical and economic reasons the author suggests two types of examination in gastro-intestinal cases. The first of these consists of the standard or routine examination which should be sufficient but not over-elaborate. The second type of examination comprises various special technics, as examination of the esophagus by all available methods, study of the rugal pattern, investigations of the small intestine and colon. All patients should be thoroughly examined by the standard method. All cases presenting the slightest evidence of pathology, even of a questionable nature, at the routine examination, and all cases with definite clinical findings of pathology and negative routine examinations, are to be recalled for further roentgen examination by means of the special technics.

J. N. Ané, M.D.

Dystopy of the Colon after Phrenic Exeresis. Burkhard Kommerell. Röntgenpraxis, February, 1936, **8**, 102, 103.

In a patient who had had a phrenicectomy eight years previous to examination, a roentgenogram of the chest showed a high diaphragm on the right and air under the diaphragm, which appeared to be in the colon. A colonic enema showed an interposition of the right side of the transverse colon between the liver and the right diaphragm. Symptoms were not complained of. The author believes that the displacement of the colon is due to the previous operation.

Hans W. Hefke, M.D.

Gastric Diverticulum Below the Cardia; Problems of Radiologic Diagnosis. Jean Charles Roux and Henri Béclère. Arch. d. Mal. de l'App. Digestif, May, 1936, **26**, 593–596.

The authors report a case of gastric diverticulum which was first seen upon routine examination in 1927. It devolved upon them nine years later to examine the same patient and to their surprise no evidence of diverticulum could be made out, even after a prolonged and varied examination. They hazard the opinion that there was probably inflammatory swelling of the narrow entrance to the diverticulum which prevented the ingress of barium, and, recalling a number of cases in which similar experiences were encountered, deem it imprudent to consider that a previously shown diverticulum does not exist because it is not visualized at a later examination.

Though gastric diverticula have been considered rather rare the authors call attention to the fact that during the last three months a large number of cases have been reported to the Gastro-enterological Society

of Paris and believe such occur more frequently than is thought, being found if searched for systematically.

Attention is also called to the fact that the presence of a gastric diverticulum does not always solve the clinical problem, inasmuch as 30 per cent of these are accompanied by associated lesions such as gastric and duodenal ulcers as well as different types of tumors.

JOSEPH DAUKSYS, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

Encrustation of the Bladder as a Result of Alkaline Cystitis. H. G. Letcher and N. M. Matheson. British Jour. Surg., April, 1936, **23,** 716–720.

The authors report a case of alkaline cystitis followed by encrustation of the bladder. The onset of the attack was in the early months of pregnancy. The bladder wall was outlined in skiagrams and almost the entire bladder was affected. Although the voided urine was strongly alkaline, specimens secured by ureteric catheterization were acid. In the authors' case, repeated examinations failed to isolate the *B. proteus ammoniæ* from the urine. The remarkable benefit which followed lavage with acid solutions appears to be unusual.

DAVIS H. PARDOLL, M.D.

Unilateral Renal Agenesis. Temple Ainsworth. Southern Med. Jour., June, 1936, **29,** 619–622.

The author recommends the classification of renal agenesis as presented by Gutierrez, in order to avoid confusion in the future. The incidence, embryology, clinical importance, signs, symptoms, and diagnosis are reviewed. Two additional cases of renal agenesis are supplemented by the writer. In Case 1, the importance of a careful urologic and urographic examination, even in an emergency operation and lacerated kidney, is illustrated. In Case 2, the finding of a rudimentary structure microscopically composed of glomeruli and tubules with no excretory function and a nonpatent ureter, is typical of a congenital aplastic kidney. In both of the reported cases there was an associated congenital anomaly. An abstract of the discussion appears along with the article.

DAVIS H. PARDOLL, M.D.

Kidney Function in Acute Calculous Obstruction of the Ureter: Some Observations of Kidney and Ureter Function in Acute Calculous Obstruction of the Ureter, Based on Excretory Urography. Leslie F. Wilcox. Am. Jour. Roentgenol. and Rad. Ther., November, 1935, **34,** 596–605.

In acute calculous obstruction of the ureter certain characteristic findings are evident in excretory urography. The urographic finding of three clinical cases, together with experimental studies in rabbits, indicate that there is retardation of urinary secretion from the kidney on the affected side and no pyelogram or ureterogram is obtainable; however, the kidney function does not cease as there is increased density of the kidney shadow. As the pain and obstruction are relieved by the administration of morphine the secretory function promptly returns to a normal level so that from 30 to 60 minutes after the injection of the dye there may be obtained for the first time a good pyelogram and ureterogram down to the level of the calculus. Pain in acute calculous obstruction is attributable to increased pressure and distention of the ureter, kidney pelvis, and capsule, and not to the presence of the calculus in the ureter producing spasm.

In conducting an intravenous urographic examination, therefore, particularly in the presence of a suspected calculous obstruction, the study must be continued late into the period of complete excretion of the dye if all valuable information is to be obtained.

J. E. HABBE, M.D.

Diagnosis of Traumatic Lesions of the Urinary Tract, with Special Reference to the Value of Excretory Urography. Fred O. Coe. Am. Jour. Roentgenol. and Rad. Ther., February, 1936, **35,** 218–225.

Trauma of the organs of the urinary tract is now more common than formerly, owing to automobile and industrial accidents and to strenuous sports.

Excretory urography affords a safe, rapid, and very accurate method of diagnosis of traumatic lesions of the urinary tract. In all such cases it is the method of choice and in children is often the only method practicable. There are no increased hazards of infection and practically no reports of untoward reactions. In some, the diagnosis is not conclusive owing to complete cessation of the kidney function or failure to fill, due to back pressure from a blood clot in the pelvis. At times, it is necessary to wait as long as two hours for a kidney image.

The roentgen finding from the flat films may be presumptive, such as fracture of the lower ribs adjacent to the kidney, fracture of the transverse processes, or obliteration of the psoas muscle and kidney on the affected side. Retrograde pyelography should be avoided due to the hazard of infection plus the added shock of instrumentation. The clinical findings must also be considered as well as the type of lesion. Both of these are discussed.

S. M. ATKINS, M.D.

Adenocarcinoma of the Jejunum. Miklos Weisz. Röntgenpraxis, January, 1936, **8,** 28–31.

An incomplete small intestinal obstruction is often the first x-ray symptom of a cancer of the small intestine. That symptom is not consistently present. The actual demonstration of the filling defect by repeated examinations should be possible in most cases.

H. W. HEFKE, M.D.